CHART NO. 11 A

Technical Information from the Varian Associates Instrument Division.

VARIAN ASSOCIATES, PALO ALTO, CALIF.

INSTRUMENT DIVISION

VARIAN associates

model G-11A

strip-chart recorder

VARIAN associates

INSTRUMENT DIVISION

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TYPE B1 INPUT CHASSIS

INTRODUCTION

The Type B1 Attenuator Input Chassis is a standard input chassis for use with any Model G-11 or G-11A Strip-Chart Recorder. The step-attenuation feature of the B1 chassis allows d-c input signals to be measured and recorded in nine voltage spans from 10 millivolts through 100 volts (see Figure 1). For the 10-millivolt span, the Type B1 Input Chassis has a recording accuracy of 1 percent of span; for all other spans, accuracy is 2 percent of span.

SPECIFICATIONS

These specifications apply to the G-11A Recorder with the Type B1 Input Chassis.

Span

10, 20, 50, 100, 200, and 500 mv (millivolts)
1, 10, and 100 volts

Full-Span Balancing Time

1 second

Limit of Error

1 percent on 10-mv range
2 percent on all other ranges

Reference System

Mercury cell

Sensitivity (1/2 deadband)

1/4 percent of span

Input Resistance

10-mv span, 1/2 megohm or greater

20, 50, 100 and 200, 500, 1000-mv spans, 0.1 megohm

10-volt span, 1 megohm

100-volt span, 10 megohms

Maximum Permissible Source Resistance

50K ohms at 10-mv span. No limitation by recorder at other spans. See input resistances.

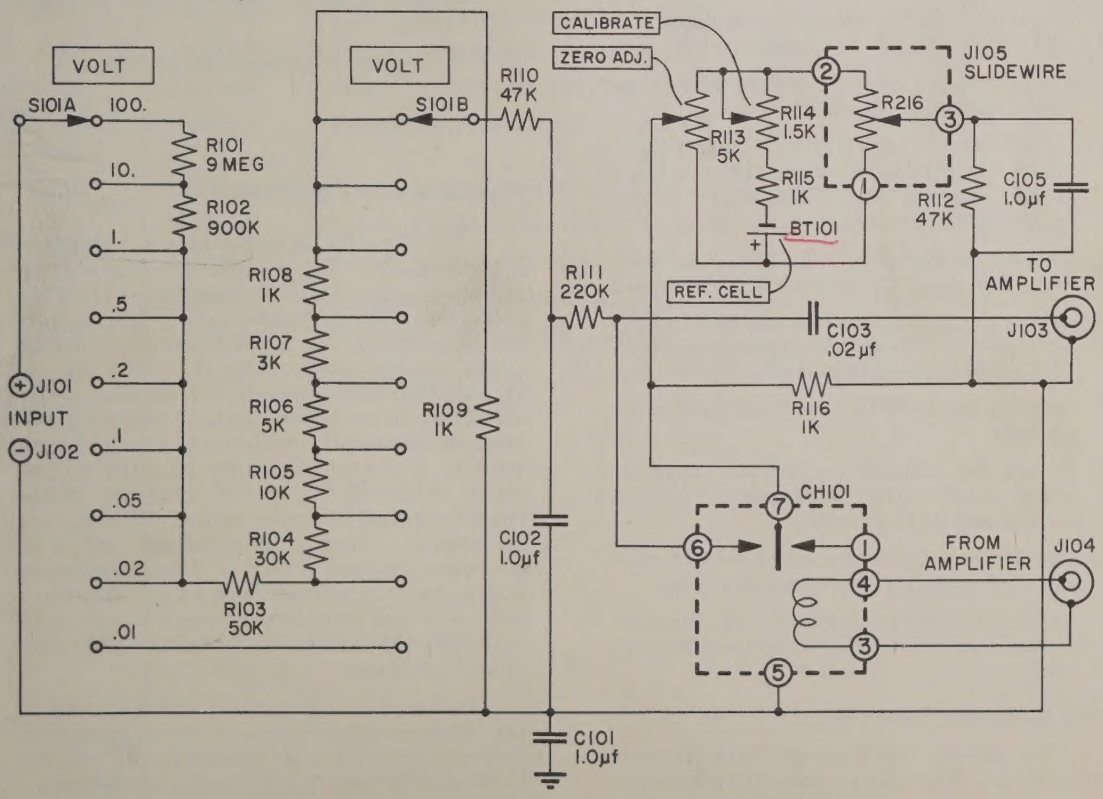

Figure 1 Schematic, Type B1 Input Chassis

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TABLE A OPERATING CONTROLS AND FUNCTIONS

CONTROL	FUNCTION
ZERO ADJ. (R113)	Allows continuous adjustment of pen-zero position to any point on chart. Also permits approximately 20-percent zero-offset on either end of chart.
REF CELL Holder	Contains mercury reference-cell (BT101) used to provide reference voltage.
CALIBRATE (R114)	Adjusts span of instrument to rated value. Also compensates for reference-cell discharge.
Attenuator VOLT Switch (S101)	Adjusts signal-input voltage so that servo-amplifier input is always within same voltage range.

Input Circuit

Isolated from ground but not balanced. Signals floating above ground by as much as 200 volts are permissible with proper considerations.

Power Requirements

110-120 volts, 1 phase, 58-62 cps, 55va maximum. Power factor approximately 0.7.

INSTALLATION INSTRUCTIONS

To replace your present input chassis with the Type B1 Input Chassis, proceed as follows:

(a) Remove recorder chassis from case (see Section 4.5.2 in G-11A Manual).

(b) Remove power-chassis cover and then remove input-chassis cover.

(c) Remove input chassis from recorder chassis by removing two screws at front corners of input chassis (and, if necessary, screw in center of input chassis).

(d) Remove plugs from J103, J104, and J105; remove chopper from present input chassis.

(e) Remove input-chassis cover from B1 chassis. Insert chopper in B1 socket and secure with chopper mounting bracket.

(f) Insert plugs in J103, J104, and J105 of B1 chassis.

(g) Secure B1 chassis to recorder chassis, using screws and lockwashers removed from other input chassis.

(h) Install input-chassis cover on B1 chassis and then install power-chassis cover.

(i) Replace recorder chassis in case, remembering first to insert power cord through case.

OPERATING INSTRUCTIONS

To operate the Type B1 Input Chassis, with either a Model G-11 or G-11A Recorder, proceed as follows (see Table A for operating controls and functions):

(a) Adjust span of recorder for 10-millivolt operation (see Section 4.5.5 in G-11A Manual). NOTE: Older Model G-11 Recorders must have GAIN control located on amplifier chassis, as in Figure 25 of G-11A Manual. For information on Gain Control Kits, consult Instrument Division Service Department.

(b) Adjust attenuator VOLT switch for desired voltage span. Connect desired signal source to input terminals.

(c) Adjust ZERO ADJ. control to place recording pen at desired zero position. NOTE: Damping is fixed with the Type B1 Input Chassis.

(d) Record desired signal information.

PRINCIPLE OF OPERATION

The Type B1 Input Chassis is, basically, a 10-millivolt Type A1 Input Chassis with an adjustable voltage divider (see Figure 1). This adjustable voltage divider is arranged so that the input voltage to the measuring circuit is always, at full-span voltage, 10 millivolts. In all positions other than the 10-millivolt (0.01 VOLT) position, a dropping-and-sampling resistance network is connected to the input terminals. For example, in the 50-millivolt position (0.05 VOLT), an 80K dropping resistance is placed in series with a 20K sampling resistance. Thus a 50-millivolt, full-span d-c signal across a total of 100K resistance will produce a current of 0.5 μa. This current of 0.5 μa will then produce a voltage of 0.01 volts (10 millivolts) across the 20K sampling resistance.

In the 10-millivolt (0.01 VOLT) position, the input circuit of the recorder is similar to the basic potentiometer measuring circuit described in Section 3.2 of the G-11A Manual.

ELECTRICAL PARTS LIST

Schematic Reference	Part	Description	Varian Part No.
BT101	Battery	Mercury reference (Mallory RM-12R)	1.4V 74-101 550
C101, C102	Capacitor	Fixed, plastic, 1.0-μf, 200v	41-729 897
C103	Capacitor	Fixed, paper, 0.02-μf, 400v	41-346 852
C104		Deleted	
C105	Capacitor	Fixed, plastic, 1.0-μf, 200v	41-729 897
CH101	Chopper		901335
J101	Connector	Binding-post, red	51-799 999
J102	Connector	Binding-post, black	51-799 990
J103, J104	Connector	Receptacle	51-471 980
J105	Connector	Receptacle	54-233 990
R101	Resistor	Fixed, composition, 9-meg, 1/2w, 1/2%	31-684 790
R102	Resistor	Fixed, composition, 900K, 1/2w, 1/2%	31-887 690
R103	Resistor	Fixed, composition, 50K, 1/2w, 1/2%	31-887 550
R104	Resistor	Fixed, composition, 30K, 1/2w, 1/2%	31-887 530
R105	Resistor	Fixed, composition, 10K, 1/2w, 1/2%	31-887 510
R106	Resistor	Fixed, composition, 5K, 1/2w, 1/2%	31-887 450
R107	Resistor	Fixed, composition, 3K, 1/2w, 1/2%	31-887 430
R108, R109	Resistor	Fixed, composition, 1K, 1/2w, 1/2%	31-887 410
R110	Resistor	Fixed, composition, 47K, 1/2w, 10%	32-202 547
R111	Resistor	Fixed, composition, 220K, 1/2w, 10%	32-202 622
R112	Resistor	Fixed, composition, 47K, 1/2w, 1%	31-688 547
R113	Resistor	Variable, composition, 5K, 2w	36-895 450
R114	Resistor	Variable, wire-wound, 1.5K, 2w	37-586 415
R115, R116	Resistor	Fixed, composition, 1K, 1/2w, 1%	31-688 410

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INSTRUMENT DIVISION

instruction sheet

TYPE T2 THERMOCOUPLE INPUT CHASSIS

1.0 GENERAL INFORMATION

The T2 Thermocouple Input Chassis is a standard input chassis for use with Varian Model G-11 and G-11A Strip Chart Recorders. The T2 Input Chassis incorporates a temperature-responsive element in the measuring circuit which automatically compensates for changes in ambient temperature at the thermocouple reference junction. The thermocouple reference junction is actually made at the recorder, the thermocouple wire being connected directly to the recorder input terminals.

The G-11A with T2 Chassis may be used with common thermocouple types over a variety of ranges. Range and thermocouple type may be changed by front panel plug-in range elements. A tabulation of standard range elements may be found in the enclosed T2 Input Chassis Data Sheet. Range elements other than standard are available on special order.

2.0 SPECIFICATIONS

The following specifications apply to the G-11A Recorder equipped with Type T2 Input Chassis:

Spans . . . . See Data Sheet at back of these instructions.

Measuring Circuit . . . . . Potentiometer

Limit of Error . . . . . 1% of span

Balance Time . . . . . 1 second full-span

Dead-band . . . . . 1/2% of span

Voltage Reference. . . Continuous electronic (Zener diode)

Thermocouple Reference Junction Compensation Method . . . . . Internal temperature-responsive element (in thermal contact with input terminals) in measuring circuit.

3.0 THEORY OF OPERATION

3.1 GENERAL DESCRIPTION

The T2 Chassis is designed to allow interchangeable selection of ranges and thermocouple types. A plug-in range element is provided for each combination of temperature range and thermocouple type. Once the controls of the recorder have been adjusted for proper calibration and operation on any range, the range elements may be changed without the necessity of readjustment.

3.2 CIRCUIT DESCRIPTION

R104 is a temperature-sensitive resistor which is thermally located at the thermocouple reference junction. The change of resistance of this device with ambient temperature change causes a change in voltage which cancels the change in voltage generated at the reference junction. This causes the recorder to read absolute temperature without regard to the exact reference junction temperature.

R401 and R402 are used to adjust the temperature compensation to match any desired thermocouple characteristics. These resistors are chosen to make the rate-of-change of voltage with temperature match the thermocouple characteristic.

A power supply regulated by a Zener diode is used to provide a constant voltage to the circuit. This voltage is applied to R216, the servo-driven potentiometer in the recorder. R103A and R103B operate differentially to shift the voltage on R216 and serve as a zero control. R106, R404, and the combination of R101 and R102 serve as a voltage divider to attenuate the output of R216 in order to match the desired range.

The thermocouple voltage is fed into the attenuator at the junction of R106 and R404 through chopper CH101. The action of the chopper causes a line frequency square wave to appear in the attenuator if the voltage delivered from R216 through R106 does not match the EMF of the thermocouple. This a-c voltage is taken out of the circuit at the junction of R404, R101, and R102, and applied to the amplifier through C103. The a-c voltage is amplified and delivered to a two-phase motor which drives the slider on R216 until balance is achieved. The a-c signal is taken out at a point which does not change amplitude appreciably when ranges are changed. This is done to avoid having to readjust the recorder gain control when the range is changed. C102 and R105 form a "lead network" which damps the servo system. When the slider of R216 is in

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motion, the voltage change across C102 causes current to flow in R404. This causes the signal fed to the servo motor to reverse slightly before the balance point is reached. This action brakes the motor and prevents overshooting the balance point.

4.0 INSTALLATION

4.1 INTRODUCTION

Model G-11A Recorders supplied from the factory with the T2 Input Chassis are ready for use when received. These instruments have been factory-tested and calibrated for the range element and temperature scale installed. Additional range elements have also been checked and tested for individual operation.

To install the Type T2 Input Chassis in a G-11 or G-11A Recorder, see Section 4.2. However, for Model G-11 Recorders with serial number 677A and below, the recorder GAIN control must be located in the servo amplifier; for information on Gain Control Kits, contact

VARIAN ASSOCIATES
Recorder Service
Instrument Division
611 Hansen Way
Palo Alto, California

4.2 INSTALLATION INSTRUCTIONS

4.2.1 Adjustment of Slidewire Position

G-11A Recorders having a serial number of or greater than 2350 do not require adjustment of the slidewire. Recorders with serial numbers below 2350, which have not previously been used with the T2 Input Chassis must have their slidewires adjusted to the proper zero reference point. To adjust the slidewire position, proceed as follows:

(a) Install temperature chart as in Section 2.2.2 of G-11A Manual.

(b) Remove recorder from case as in Section 4.5.2 of G-11A Manual and install pen assembly on recorder as in Section 2.2.3 of G-11A Manual.

(c) By turning sheave on top of balancing motor, move recording pen to left-hand margin of chart (i.e. 0^{o} F on chart Type 101A or -20^{o} C on Type 201A).

(d) Connect an ohmmeter across OUTER terminals on slidewire case. (Be sure recorder is not connected to a power source.)

(e) Loosen slidewire locking nut about 1/4-turn so slidewire case can be rotated.

(f) Holding slidewire sheave stationary, rotate slidewire case until ohmmeter shows indication of 100 ohms, ± 15 ohms.

If the above procedure does not bring ohmmeter to the desired position, proceed as follows:

(1) Move recording pen to extreme left position.

(2) Loosen 2 Allen-head set-screws in slidewire sheave, so that sheave can be moved laterally on slidewire shaft.

(3) Move sheave along shaft away from slidewire case.

(4) Move recording pen to left-hand edge of chart calibration, as in 4.2.1 (c) above.

(5) Without disturbing position of pen, rotate SLIDEWIRE SHAFT with suitable long-nose pliers until ohmmeter indicates 100 ohms, ± 10 ohms.

(6) Move sheave laterally toward slidewire case, taking care not to disturb ohmmeter reading. Tighten set-screws.

(7) Check position of the recording pen. Repeat steps (e) and (f) above.

(g) Tighten slidewire locking nut, making sure ohmmeter indication remains at 100 ohms. Disconnect ohmmeter.

(h) This completes adjustment of slidewire zero reference point.

The slidewire zero reference position as needed for the T2 Input Chassis may be used with all other input chassis available for the G-11A Recorder. When replacing the T2 Chassis with A1, A2, B1 or F1 Input Chassis, it is not necessary to reposition the slidewire.

4.2.2 Input Chassis Replacement

To replace your input chassis with the Type T2 Input Chassis, proceed as follows:

(a) Remove recorder from case as in Section 4.5.2 of G-11A Manual.

(b) Remove power chassis cover and then remove input chassis cover.

(c) Remove input chassis from recorder by removing two screws at front corners of input chassis and in some input chassis, screw in center of input chassis.

(d) Disconnect plugs from J103, J104, and J105 and remove chopper CH101.

(e) Remove input-chassis cover from T2 chassis. Insert chopper CH101 in T2 socket and secure with chopper hold-down bracket.

(f) Insert proper plugs in J103, J104, and J105 of T2 chassis.

(g) Secure T2 chassis to the recorder, using screws and lockwashers which were removed in step (c).

(h) Install input-chassis cover on T2 chassis. Install power-chassis cover.

(i) Replace recorder scale with proper temperature scale. Temperature scales are calibrated in ^{o}C on one side and in ^{o}F on other side.

(j) Adjust slidewire position as in Section 4.2.1 above if necessary, or not previously done.

(k) V201 and V202 MUST be 12AX7 electron tubes; change if necessary.

(l) Install temperature-calibrated chart paper, making certain paper, range element, and scale are for same thermocouple type and for same temperature range.

(m) Calibrate recorder for temperature operation as described in Section 5.2.1 of these instructions. If V202 has been replaced, GAIN control may require initial readjustment to achieve maximum gain for minimum dead-band. See Section 4.5.7 of G-11A Manual for amplifier gain adjustment.

(n) Replace recorder in case, remembering first to insert power cord through case.

(o) This completes installation of T2 Input Chassis. See Section 5.0 for operating information.

5.0 OPERATION

5.1 OPERATING CONTROLS AND TERMINALS:

ZERO ADJ. Control (R103)

Adjusts recorder to a reference temperature, usually 0^{o} C or 32^{o} F.

CALIBRATE Control (R303)

Adjusts span of recorder.

DAMPING Control (R105)

Adjusts recorder for proper damping.

Range Element

Different range elements may be used for various temperature ranges and thermocouple types.

Input Terminals (J101, J102)

For connection of thermocouple leads to recorder.

5.2 OPERATING INSTRUCTIONS

To operate G-11A Recorders equipped with Type T2 Input Chassis, proceed as follows:

(a) Check supply of chart paper and ink; replenish as necessary. Ink capacity of pen reservoir will, in most cases, exceed ink requirements of full 85-foot (25-meter) roll of chart paper.

(b) Install recording pen in spring clip; check ink flow of recording pen.

(c) Connect line cord to appropriate a-c receptacle (listed on instrument nameplate). For portable operation, recorder may be operated from inverter-type power supply rated to deliver CONTINUOUSLY a minimum of 40 watts at proper voltage and frequency.

WARNING

GROUND RECORDER BEFORE OPERATING. Model G-11A Recorders have three-wire power cord; tubular pin completes ground connection automatically. If ground pin is removed or adapter plug is not grounded manually, recorder case is placed at approximately 60 volts a-c.

(d) Turn POWER switch ON. Adjust chart speed switch (and speed shifter) for desired chart speed.

(e) Connect proper thermocouple type directly to recorder INPUT terminals, making sure negative lead (Constantan, Alumel, etc.) is connected to negative (-) BLACK input terminal. NOTE: Correct connection of thermocouple leads can be verified by warming measuring junction and noting up-scale (left-to-right) movement of recorder pen.

(f) Place thermocouple measuring junction at temperature source. (Thermocouple lead length is not critical.)

(g) Calibrate recorder as in Section 5.2.1 of these instructions.

(h) Record temperature signal.

5.2.1 Calibration

To calibrate the G-11A with T2 Input Chassis, proceed as follows:

(a) Install temperature-calibrated chart paper as in Section 2.2.2 of G-11A Manual.

(b) Connect line cord and turn POWER and CHART switches ON.

(c) Connect proper thermocouple type to input terminals on rear of T2 Input Chassis. Be sure negative leads are connected to negative recorder terminal.

(d) Place thermocouple measuring junction in ice-water bath, but not in contact with ice.

(e) After thermocouple measuring junction has been in ice bath approximately 5 minutes, adjust ZERO ADJ. control to place recording pen at 0 degrees Centigrade or 32 degrees Gahrenheit position on chart paper.

(f) Adjust recorder indicating scale laterally so pointer indicates same value on scale that pen indicates on temperature - calibrated chart paper.

(g) Connect calibration voltage source, as shown in Figure 1.

Connect positive terminal of voltage calibration source to RED input terminal of T2 Input Chassis, using same type thermocouple wire connected to negative terminal of voltage calibration source.

(h) Adjust calibration voltage source for voltage required to produce full-span deflection of recorder pen with range element used. See Table A for tabulation of calibration voltage required to produce full-span deflection from 32^{o} F or 0^{o} C.

(i) Adjust CALIBRATE control for full-span value on proper chart paper. NOTE: If V202 has been changed, adjust GAIN and DAMPING controls for maximum gain with minimum dead-band. See Section 4.5.7 of G-11A Manual for amplifier gain adjustments.

(j) Short-circuit terminals of calibration voltage source and repeat step (e).

(k) Remove short-circuit from calibration voltage source and repeat step (i).

(l) Repeat steps (j) and (k) until no further improvement results.

If full-span or zero calibration points cannot be attained, check for correct chart paper, recorder scale, thermocouple-type and polarity, and range element. If all of these items are correct, verify calibration voltage and polarity, and also verify 100-ohm setting of slidewire, as in Section 4.2.1 of these instructions.

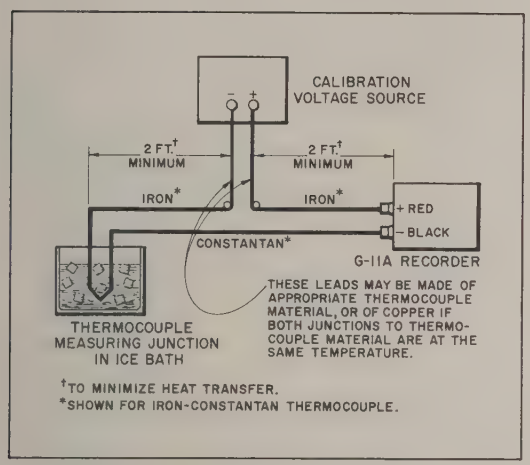
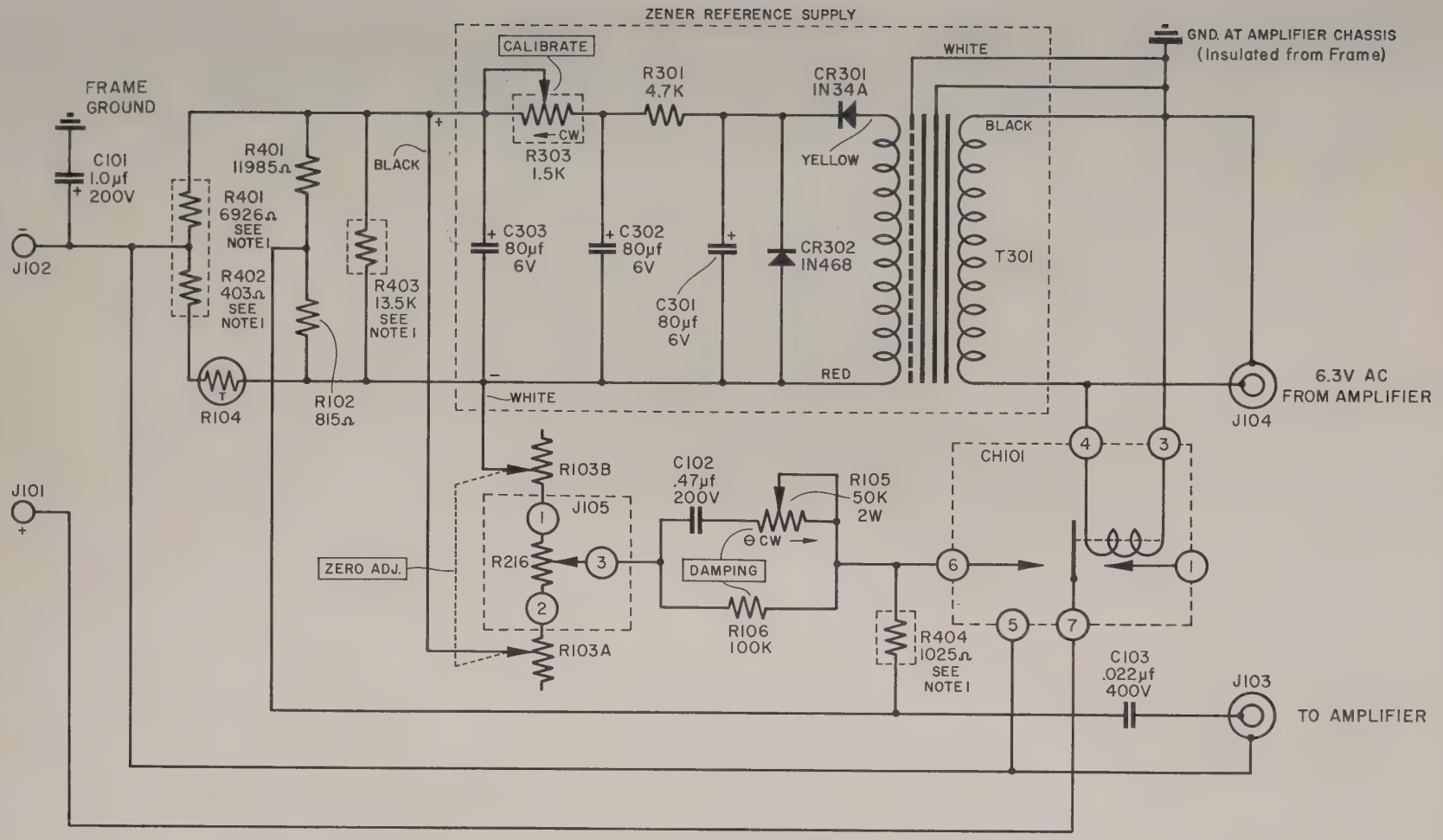

CALIBRATION VOLTAGE SOURCE
2 FT.† MINIMUM
2 FT.† MINIMUM
IRON*
IRON*
+ RED
– BLACK
CONSTANTAN*
G-11A RECORDER
THESE LEADS MAY BE MADE OF APPROPRIATE THERMOCOUPLE MATERIAL, OR OF COPPER IF BOTH JUNCTIONS TO THERMOCOUPLE MATERIAL ARE AT THE SAME TEMPERATURE.
THERMOCOUPLE MEASURING JUNCTION IN ICE BATH
†TO MINIMIZE HEAT TRANSFER.
*SHOWN FOR IRON-CONSTANTAN THERMOCOUPLE.

FIGURE 1.

RANGE ELEMENT CALIBRATION VOLTAGES

RANGE ELEMENT	FULL SPAN CALIBRATION VOLTAGE IN MILLIVOLTS	
	From 32^{o} F	From 0^{o} C
01	11.03	10.78
02	17.18	16.33
03	21.79	21.85
04	32.72	33.11
05	56.64	57.70
06	49.05	48.89
07	5.280	5.227

TABLE A.



NOTES:

1. R401 TO R404 ARE LOCATED IN THE RANGE ELEMENT
   VALUES AS NOTED ARE TYPICAL FOR 01 RANGE ELEMENT ONLY.
2. R216 IS LOCATED IN THE SERVO CHASSIS
3. R101 AND R102 COMPRISE VOLTAGE DIVIDING NETWORK, PART NO. 903414

FIGURE 2. SCHEMATIC, T2 THERMOCOUPLE INPUT CHASSIS

ELECTRICAL PARTS LIST, T2 INPUT CHASSIS

Schematic Reference	Part	Description	Varian Part No.
C101	Capacitor	Fixed, Mylar, 1-μf, 200v	41-729 897
C102	Capacitor	Fixed, Mylar, 0.47-μf, 150v	41-719 886
C103	Capacitor	Fixed, paper, 0.022-μf, 400v	41-346 852
C301, C302, C303	Capacitor	Fixed, electrolytic, 80-μf, 6v	41-509 999
CH101	Chopper		901335
CR301	Diode	Type 1N34A	66-398 990
CR302	Diode	Type 1N468	66-397 943
J101	Connector	Binding post, red	51-799 960
J102	Connector	Binding post, black	51-799 961
J103, J104	Connector	Receptacle	51-471 980
J105	Connector	Receptacle, 3-pin	54-233 990
J106	Connector	Receptacle, miniature, 9-pin (tube type)	54-209 990
R101, R102	Resistor	Voltage-dividing network	903414
R103A R103B	Resistor	Variable, wirewound, dual	903340
R104	Resistor	Temperature-compensating	941482
R105	Resistor	Variable, wirewound, 50K, 2w, 5%	37-586 550
R106	Resistor	Fixed, wirewound, 100K, 1/4w, 1/2%	31-299 610
R301	Resistor	Fixed, deposited-carbon, 4.7K, 1/2w, 1%	31-688 447
R302		Deleted	
R303	Resistor	Variable, wirewound, 1.5K, 2w, 5%	37-586 415
R401, R402, R403, R404	Resistor	Located in Range Element	
T301	Transformer	Power, Zener supply	901723

ELECTRICAL PARTS LIST, T2 INPUT CHASSIS

Schematic Reference	Part	Description	Varian Part No.
# 01	Range Element	Iron-Constantan (Type J) 0 to 400° F; -20 to 200° C	941495-01
# 02		Iron-Constantan (Type J) 0 to 600° F; -20 to 300° C	941495-02
# 03		Iron-Constantan (Type J) 0 to 750° F; -20 to 400° C	941495-03
# 04		Iron-Constantan (Type J) 0 to 1100° F; -20 to 600° C	941495-04
# 05		Iron-Constantan (Type J) 0 to 1800° F; -20 to 1000° C	941495-05
# 06		Chromel-Alumel (Type K) 0 to 2200° F; -20 to 1200° C	941495-06
# 07		Copper-Constantan (Type T) -150 to 250° F; -100 to 120° C	941495-07

ERRATA SHEET

for

G-11A GRAPHIC RECORDER INSTRUCTION MANUAL

Please make the following changes in the instruction manual supplied with your instrument:

page 3-2 Change value of R110 to read: 100K

Change value of C102 to read: 0.47-μf

page 3-4 On Zener Ref. Supply schematic, change value of capacitors C301, C302, and C303 to read: 80-μf, 6 volts

Insert [CALIBRATE] above resistor R303. This control is now located on the front panel of Type A2 Input Chassis.

page 3-7 Change pin number designations of plug P205 to read: (1) (3) (2)

page 4-6 Change Figure 23 as follows:

Add arrow from INPUT-CHASSIS MOUNTING SCREWS callout to chassis access-hole directly above callout.

Delete R303 callout and arrow

Delete entire second sentence in Section 4.5.4.2

page 4-7 In Section 4.5.7,

Delete (a)

Change (f) to read "Rotate screwdriver adjust GAIN control, located on front panel above ZERO ADJUST control, to extreme clockwise position."

In Figure 25, delete words "GAIN CONTROL"

page 4-8 In section 4.5.7, delete (i)

page 5-7 Change C301, C302, C303 description and P/N to read:

Fixed, electrolytic, 80-μf, 6v; part number 41 509 999

page 5-8 Change R110 description and part number columns to read:

Fixed, composition, 100K, 1/2w, 10%; part number 32 202 610.

NOTE: R110 in F1 Input Chassis remains 1.3K, as indicated in manual.

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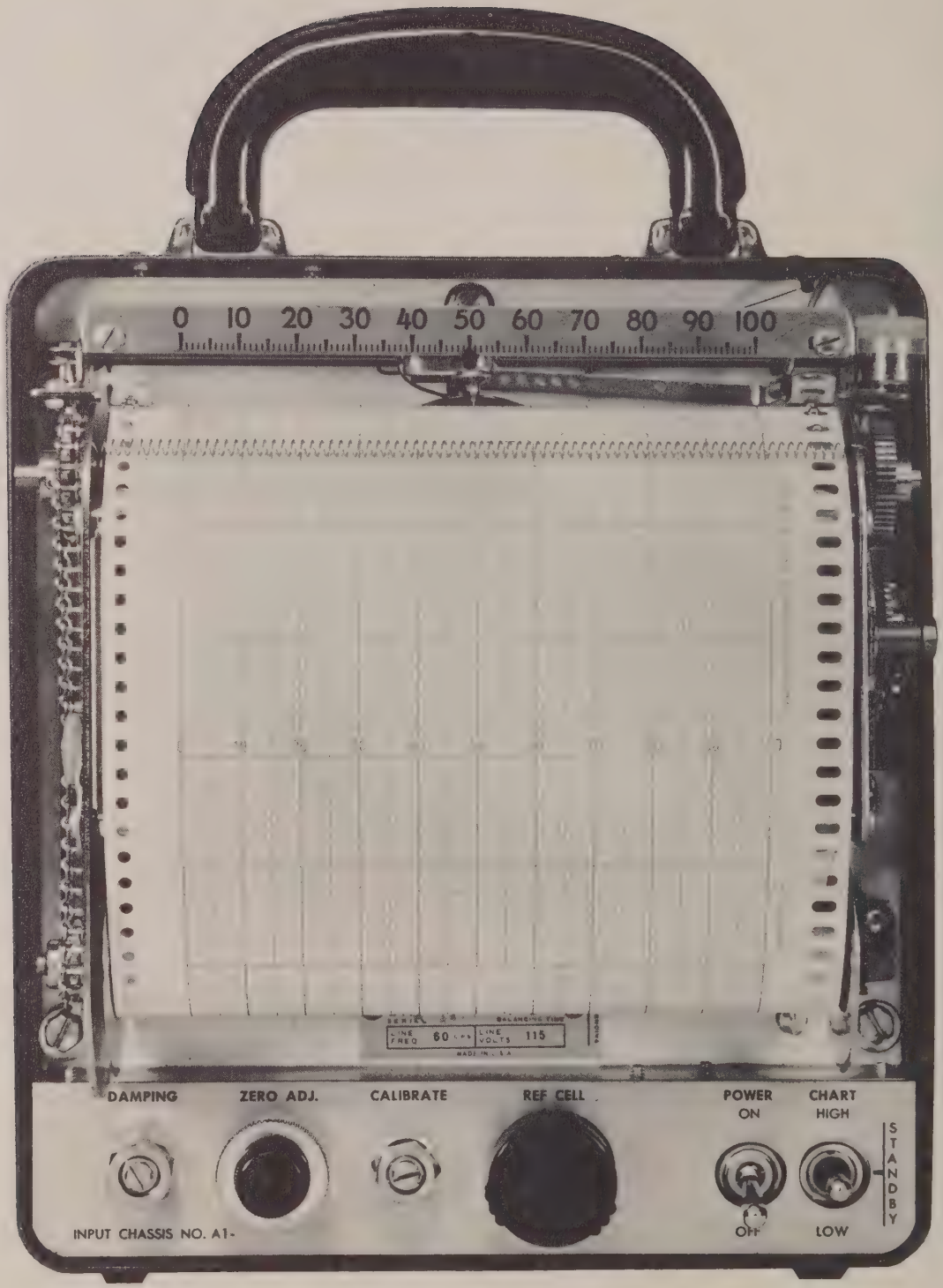


Figure 1 The Varian Model G-11A Strip-Chart Recorder

1.0 GENERAL INFORMATION

1.1 INTRODUCTION

The Varian Model G-11A Strip-Chart Recorder is a laboratory-quality electronic instrument for measuring and recording accurately any phenomenon capable of being translated into an appropriate d-c voltage. Available in either portable or panel-mounting versions, the Model G-11A Recorder permanently records full-span voltage measurements from 9 through 100 millivolts.

The Model G-11A is a true rectilinear recorder operating on the automatic null-balancing potentiometer principle, long proven to be a most stable, accurate, and reliable method of measurement. The accuracy of the system, which is 1 percent of the span, is obtained by the use of precision components; the stability is obtained by the use of either mercury reference cells or Zener diodes. The automatic balancing feature of the system, which is obtained by the use of a narrow-band, high-gain servo amplifier, results in freedom from zero drift and extremely low current drain from the device under measurement.

An ever-increasing number of unitized, interchangeable input chassis allow the recorder to be used directly with many different types of information sources, without additional external circuitry. The Model G-11A Recorder may also be adapted to applications involving the measurement of physical quantities such as temperature or pressure, weight or force, strain or displacement, and speed or light intensity.

1.2 COMPONENTS AND FUNCTIONS

The Model G-11A Recorder system, which is illustrated in Figure 2, consists of the INPUT CHASSIS, which contains the measuring circuit and chopper used to detect and convert the voltage difference between the input voltage and the reference voltage; the SERVO AMPLIFIER, which amplifies the difference voltage to the level required to operate the balancing motor; the BALANCING SYSTEM, which continuously detects and cancels the differences between the input signal and the reference signal by mechanically coupling the balancing motor to the measuring circuit; and the CHART-DRIVE SYSTEM, which continuously records the mechanical changes in the balancing system.

1.3 PRINCIPLE OF OPERATION

The principle of operation of the Model G-11A Recorder is based on the potentiometer, a precision laboratory instrument for accurately measuring differences of potential (voltage).

The basic potentiometer, as shown in Figure 3, consists of an indicating device and an accurately known standard voltage with a calibrated, precision slidewire voltage-divider. When the voltage between the positive (+) terminal of the potentiometer and the movable contact of the slidewire is exactly the same as the unknown voltage, the indicator will show a zero (or null) reading. The value of the unknown voltage is then read directly from the calibrated slidewire.

In the Varian recorder, the potentiometer has been modified to incorporate such features as damping, span and zero adjustments, automatic null-balancing, and permanent-record indications.

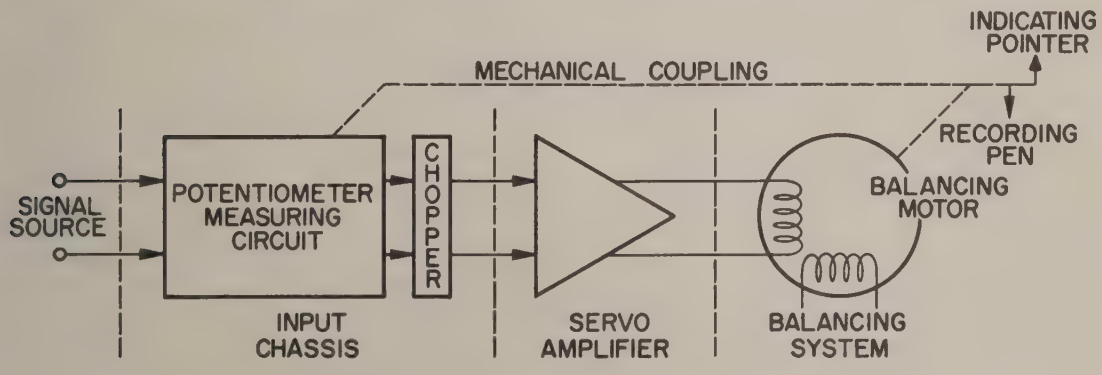


Figure 2 Block Diagram, Model G-11A Recorder

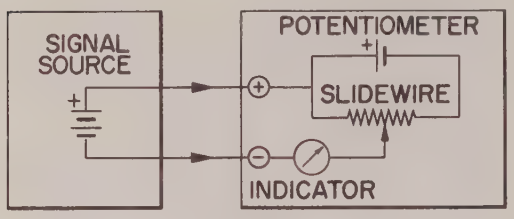


Figure 3 Basic Potentiometer

1.4 EQUIPMENT SUPPLIED

The basic Model G-11A Strip-Chart Recorder, which is available in either portable or panel-mounting versions, is supplied with the items listed below (portable recorders are supplied with carrying handle and rubber feet; panel-mounted recorders are supplied with one bezel and all necessary hardware for mounting the recorder in a panel):

(a) G-11A Recorder (see Data Sheet in rear cover for dimensions)

(b) Recording pen with plastic cap

(c) Pen cleaner

(d) One roll of chart paper

(e) One re-roll tube

(f) One spare reference cell (if used)

(g) One instruction manual

1.5 ACCESSORIES, SUPPLIES, AND OPTIONAL FEATURES

Available accessories, supplies, and optional mechanical and electrical features are listed on the literature contained in the back cover of this instruction manual.

1.6 SPECIFICATIONS

Electrical and mechanical specifications for the recorder are listed on the Data Sheet in the back cover of this manual.

1.6.1 Definitions

The following definitions may be of assistance in interpreting the specifications for the Model G-11A Recorder.

(a) SPAN is defined as the algebraic difference between the top scale value and the bottom scale value expressed in scale units.

(b) FULL-SPAN BALANCING TIME is defined as the time required for the instrument to come within 1 percent of balance when a full-span step-function voltage is applied to the recorder.

(c) LIMIT OF ERROR is defined as the maximum amount by which the indicated value of the measured variable can vary from the true value of this variable. A 1 percent limit-of-error figure corresponds to an accuracy of ±1 percent of span.

(d) DEAD-BAND is defined as the maximum difference (in percent of span) between the indicated values of the measured variable when balance is approached from above and below the true value.

installation and operation

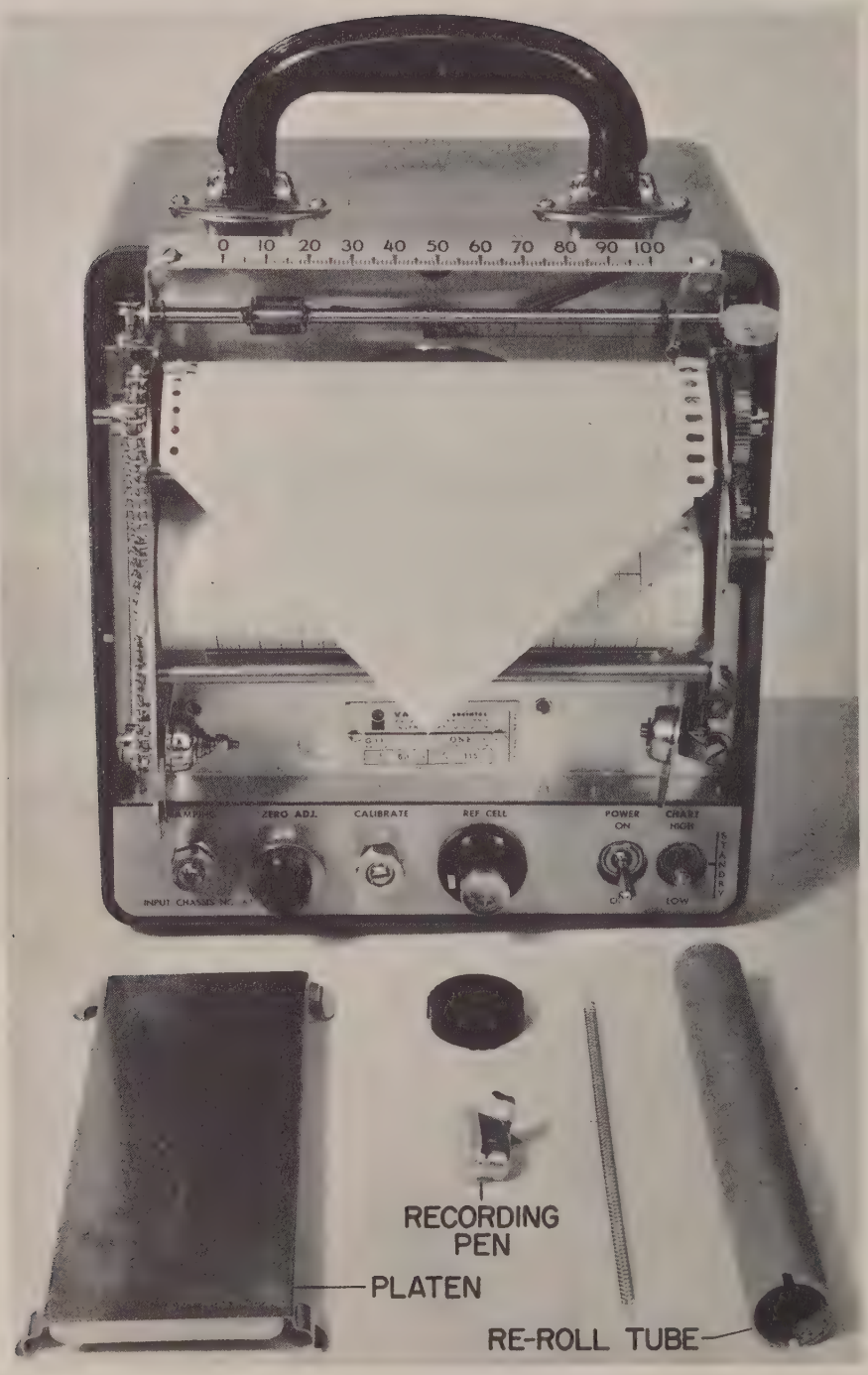


Figure 4 Chart-Paper Installation

2.0 INSTALLATION AND OPERATION

2.1 INTRODUCTION

The Model G-11A Recorder is available with numerous optional features such as an event marker, a speed shifter, an additional chart-drive motor, and a number of input chassis. Therefore, to attain optimum usefulness, the instrument described will be equipped with a Type A1 Input Chassis and all optional features except inkless recording; other input chassis will be discussed in subsequent sections.

2.2 INSTALLATION INSTRUCTIONS

2.2.1 Introduction

These instructions pertain to chart-paper and recording-pen installation only. For information on service adjustments such as chart-motor replacement and ladder-chain adjustments, consult Section 4.

2.2.2 Chart-Paper Installation

The following installation procedure for all types of chart paper assumes the recording pen is not installed (please refer to Figures 4 and 5 for parts nomenclature).

(a) Remove instrument front cover by depressing both front-cover release buttons and swinging cover forward and up.

(b) Remove platen covering chart compartment by "springing" platen off circular rods.

(c) Fold back chart-paper corners toward center of paper, as shown in Figure 4. (Save masking tape for use in step (i).)

(d) With printed side of chart toward rear of instrument insert pointed end of chart paper through slot behind chart-drive drum.

(e) Insert chart-paper roll in chart compartment and snap platen in place on circular mounting rods. NOTE: If spring clips do not engage rods properly, bend clips slightly to change spring tension.

(f) Place shifter lever in N (neutral) position, grasp folded end of chart paper and front portion of ladder chain on left-front side of recorder. Simultaneously pull chart paper forward and ladder chain down to engage sprocket teeth in chart-paper perforations.

(g) Continue pulling chart paper forward until chart-paper perforations are squarely engaged in sprocket teeth. If necessary, lift chart-paper hold-down clips (and event-marker pen) to make adjustment.

(h) Roll chart paper forward until approximately 8 inches (20 mm) are available in front of hold-down clips.

If, instead of using chart take-up unit, it is desired to have chart feed out of slot in bottom of front cover, insert chart paper behind chart-retainer spring and feed free end of chart through slot from inside of cover.

(i) Unfold corners of chart paper and, with notched end of cardboard re-roll tube toward left-hand take-up disk, attach chart paper to re-roll tube with masking tape removed in step (c). Wind one or two turns of chart paper on re-roll tube. NOTE: Center chart paper on re-roll tube.

(j) Place re-roll tube on left-hand take-up disk, move right-hand take-up disk (re-roll release tab) to right and insert re-roll tube on right-hand take-up disk (see Figure 5).

(k) Hold left-hand ladder chain stationary and rotate left-hand take-up disk until projection on disk slips into notch on re-roll tube.

(l) Pull ladder chain down to check operation and tautness of chart paper across platen

Figure 5 Chart-Paper Installation

and re-roll tube. If chart paper is not centered or is loosely wound on re-roll tube repeat steps (i) through (k).

2.2.3 Recording-Pen Installation(s)

To install the recording pen proceed as follows (these instructions, which also apply, in part, to the event marker, assume the pen is clean and the capillary pen-opening is unobstructed. Instructions regarding the care and cleaning of the pen are found in Section 4.):

(a) Remove plastic ink-reservoir cap and fill pen reservoir as desired. Replace reservoir cap to prevent fast-drying ink from evaporating and clogging pen.

(b) Raise indicating scale and spring-clip holder. Insert one end of pen reservoir in holder and slide other end in place.

(c) Push pen reservoir down until pen-point contacts, and is perpendicular to, chart paper.

(d) Lift pen off chart paper and prime by applying thumb pressure to plastic reservoir cap. This should cause ink droplet to appear at pen point. Release recording pen.

(e) Check correlation between pointer and pen point. If necessary, loosen indicating-scale mounting screws and position scale as required. Tighten mounting screws. NOTE: Remove pen cleaner shipped in event-marker pen.

2.2.3.1 Inkless Stylus

To install the inkless stylus assembly, proceed as follows:

(a) Loosen screw on top of stylus assembly.

(b) Insert spring clips on pen carriage into clamp on stylus assembly.

(c) Position stylus assembly so that stylus is perpendicular to chart paper. Tighten screw.

(d) When assembly is properly installed, stylus assembly is parallel with pen-carriage rod and stylus is vertical.

2.2.4 Panel-Mounted Recorders

Panel-mounted recorders are supplied with all the items necessary for mounting the recorder in a panel. Construction details for panel-mounting are found on the Data Sheet (see rear cover of this manual).

2.3 OPERATING INSTRUCTIONS

2.3.1 Operational Remarks

2.3.1.1 Recorder Response

The Model G-11A Recorder is designed for recording applications involving relatively slow changes in d-c signal levels. The Model G-11A reproduces all slowly varying d-c signals compatible with the 1-second, full-span balancing time of the recorder. The appearance of alternating currents at the input terminals may result in substandard recorder performance and certain precautions are necessary to prevent this condition.

The input circuit of the recorder incorporates an R-C filter (R110, C102) to minimize power-line frequency components. However, if the a-c component of the input signal is large in comparison with the low-frequency or d-c component, the effects of this filter may be reduced.

Undesirable a-c signals may be eliminated by using shielded wire to connect the signal source to the recorder. If shielded wire is used, it should only be grounded at the negative terminal of the recorder; connecting both ends of the shield can produce serious ground loops, especially if large magnetic fields are present. However, most low-impedance sources will not require shielding and simple twisted-pair leads may be used.

Impaired recorder performance may also result from the production of large a-c voltages between J102 and recorder-chassis ground. These voltages will, of course, appear across C101; they may also appear across the input terminals. This type of interference may be remedied by connecting a large capacitor (10 μf, etc.) between J102 and recorder-chassis ground.

Since the input terminals are not balanced, recorder performance may also be impaired when balanced voltages, with respect to ground, are applied to the input terminals. Under these conditions, isolate either the signal source or the recorder from the a-c power line by an electrostatically shielded isolation transformer. In locations with large a-c magnetic fields present, it may even be impossible to operate the recorder.

2.3.1.2 Balancing Time

FULL-SPAN BALANCING TIME for the Model G-11A Recorder is defined as the time required for the instrument to come within 1 percent of balance when a full-span step-function voltage is applied to the input terminals. Figure 6 illustrates a typical curve for a Model G-11A Recorder.

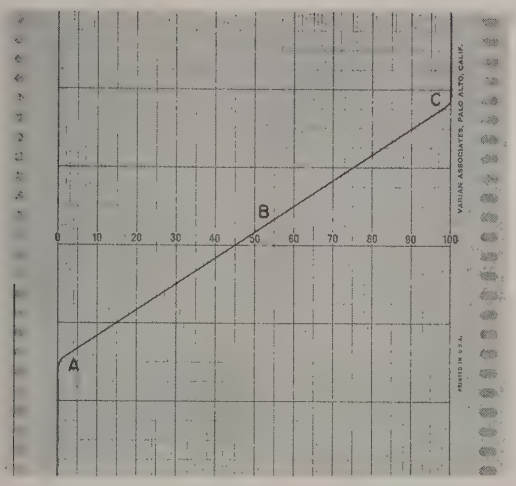


Figure 6 Full-Span Balancing Time

The curve in Figure 6 has three distinct portions: A, acceleration time, B, full-speed time, and C, deceleration time. The acceleration time is approximately 0.1 seconds, the full-speed time is approximately 0.8 seconds, and the deceleration time is approximately 0.05 seconds. These values are nominal, since recording-pen velocity is a function of

(a) Percent of span represented by input signal

(b) Amount of damping

(c) Value of a-c line voltage and frequency (nominal full-span balancing time is based on operation of instrument at mid-point voltage and frequency)

2.3.1.3 Ground Connections

The power-input circuit of the recorder contains a balanced-line transient suppressor (R.F. INT. FILTER). If the case is not grounded, this filter places the recorder case at approximately 60 volts. The three-wire power cord automatically grounds the recorder case and eliminates this potential. When an adapter plug is used, the recorder case must be manually grounded by connecting the external adapter-plug lead to an electrical-conduit or water-pipe ground point; the manual ground may also be made by connecting an external wire between the metal grounding post on the rear of the recorder and a suitable ground point. DO NOT NEGLECT RECORDER-CASE GROUNDING.

2.3.1.4 Source Resistance

If the source resistance is below the maximum permissible values, the Model G-11A Recorder will operate as specified on the Data Sheets in the envelope on the rear cover. It is, however, possible to use source resistances greater than those specified (up to 1/2-megohm), with a possible resultant reduction in G-11A specifications. For a 1/2-megohm source resistance and 100-millivolt span, the dead-band may approach 1 percent.

Recorder input resistance is nearly infinite at null-balance and thus draws extremely low current from the source. When the instrument is not at null-balance, the input resistance is greater than 1/2-megohm.

2.3.1.5 Floating Input (d-c signals biased above ground)

The Model G-11A Recorder may be operated with the input terminals above ground potential.

The insulation resistance of the components used in the recorder is of the order of several hundred megohms and under normal operating conditions leakage currents do not present a problem. However, when the input signal is biased above ground potential and when the recorder is operated in extremely humid environments, the high-gain characteristic of the recorder may produce an offset of the zero-voltage position as a result of the minute leakage-current paths between recorder-chassis ground and case (or earth) ground. If these are constant, the offset can be eliminated by adjustment of the ZERO ADJ. control.

2.3.1.6 Input Attenuation

Input attenuation is required when voltage variations in excess of the recorder span are being recorded. The attenuation required may be achieved by the use of a simple voltage divider or, if desired, a commercial attenuator may be used if the total input resistance remains within the Data Sheet specifications.

2.3.2 Operating Controls and Terminals

For operating controls and terminals see Table A. For operating-control adjustments see Section 2.3.4.

2.3.3 Detailed Operating Instructions

Detailed operating instructions are as follows:

(a) Check supply of chart paper and ink; replenish as necessary. Ink capacity of pen reservoir will, in most cases, exceed ink requirements of full 85-foot (25 meter) roll of chart paper.

TABLE A OPERATING CONTROLS AND TERMINALS

CONTROL	FUNCTION
Power Chassis:	
POWER ON-OFF Switch (S201)	Controls all electrical-power input to recorder
CHART HIGH-LOW-STANDBY Switch (S202)	HIGH position supplies electrical power to (basic) high-speed chart-drive motor (B202) LOW position supplies electrical power to optional low-speed chart-drive motor (B203) STANDBY position removes electrical power to chart-drive motor(s) and reference winding of balancing motor
Fuse (F201)	Fuses electrical-power input to recorder. (Use 1-ampere, 8 AG types for replacement. Recorder case and power-chassis cover must be removed to replace this item.)
Power Cord (P206)	Provides 6-foot, heavy-duty, 3-wire power connection, with tubular pin making positive ground connection. For operation from 2-lead power receptacles use an adapter plug (Cornish Wire Co. #228 or equivalent) WARNING: Always ground recorder case.
Chart HI-N-LO Speed Shifter (optional)	HI position provides standard chart speed N position disengages chart-drive roller from chart-drive motor(s) LO position reduces standard chart speed by 1/4 To operate speed shifter, disengage detent by pulling slightly on small knob at end of shifter lever
Input Chassis:	
REF CELL Holder	Contains standard-voltage mercury reference cell (BT101) used to provide reference voltage
ZERO ADJ. (R105)	Allows continuous adjustment of pen-zero position to any point on chart. Also permits approximately 20 percent zero-offset on either end of chart
CALIBRATE (R106)	Adjusts full span of instrument to rated value. Also compensates for reference-cell discharge
DAMPING (R101)	Adjusts recorder for proper signal damping for any value of source resistance within Data Sheet specifications
Input Terminals (J101,J102)	Provide isolated input for recording signals with d-c levels above ground. Red terminal is positive (+) for left-to-right pen travel
Ground Terminal	Provides auxiliary ground connection in addition to ground lead in power cord
Fine Calibrate (R303) (A2 Input Chassis only)	Adjusts full span of A2 input chassis instruments to rated value
SPAN (R109)	See Section 4.5.5
Amplifier:	
Gain (R218)	See Section 4.5.7

(b) Install recording pen in spring clip; check ink flow of recording pen (and event-marker pen).

(c) Connect line cord to appropriate a-c receptacle (listed on instrument nameplate).

For portable operation, recorder may be operated from inverter-type power supply rated to deliver CONTINUOUSLY a minimum of 40 watts at proper voltage and frequency.

> WARNING
>
> GROUND RECORDER BEFORE OPERATING. Model G-11A Recorders have three-wire power cord; tubular pin completes ground connection automatically. If ground pin is removed or adapter plug is not grounded manually, recorder case is placed at approximately 60 volts ac.

(d) Turn POWER switch ON.

(e) Connect desired signal source to input terminals.

(f) Connect event-marker voltage-source (value determined by "relay" coil rating) to terminals 1 and 2 on terminal board on rear of input chassis. Maximum repetition rate should not exceed five pulses per second. NOTE: If event-marker switching transients interfere with recording pen, isolate event-marker voltage source from a-c power line.

(g) Place CHART switch (and speed shifter) in HIGH position(s). Speed shifter is moved by lightly pulling button on shift lever to disengage detent.

(h) Unlock and adjust DAMPING control while suddenly rotating ZERO ADJ. control. If recorder is properly damped, recording pen should move quickly to new balance position with no overshoot. If overshoot occurs, rotate DAMPING control counterclockwise until overshoot just disappears; this is critical damping. NOTE: All locking devices are unlocked counterclockwise.

(i) Place recording pen at desired zero position using ZERO ADJ. control. NOTE: The zero-voltage point may be set anywhere on the chart and up to 20 percent beyond either chart limit.

(j) Position chart switch (and speed shifter) for desired chart speed. In HI position speed shifter produces same standard chart speed selected by CHART switch; LO position reduces standard speed by 1/4.

(k) Record signal; actuate event marker as desired.

2.3.4 Operating-Control Adjustments

2.3.4.1 DAMPING Control

Recorder damping is characterized by three distinct classes of recording-pen response. If the recorder is overdamped, the recording pen creeps into position when a step-function voltage is applied to the input terminals. If the recorder is underdamped, the recording pen overshoots when a step-function voltage is applied to the input terminals. If the recorder is critically damped, the recording-pen response to a step-function voltage is direct; it moves directly to the new steady balance position and does not overshoot. Figure 7 illustrates the three extreme damping conditions: curve C is underdamped, curve B is critically damped, and curve A is overdamped.

2.3.4.2 ZERO ADJ. Control Adjustments

The primary function of the ZERO ADJ. control is to position the recording pen at the desired zero position. This control is also useful for checking recording-pen response, maximum balancing-motor speed, and discharged reference cells. If the cell is discharged and the input terminals are either short-circuited or connected to a signal source, rotation of the ZERO ADJ. control will not move the recording pen from the extreme ends of the chart.

2.3.4.3 CALIBRATE Control

All Varian recorders are factory calibrated before shipment to the value specified at the time of purchase. However,

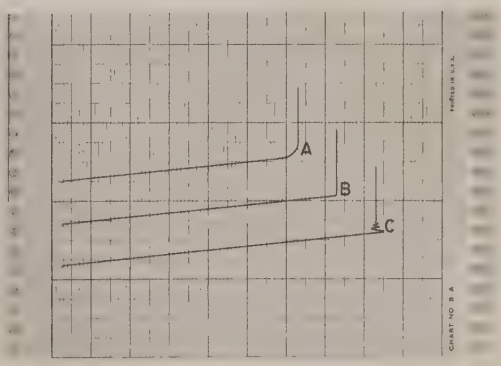


Figure 7 Recorder Damping Conditions

since the mercury reference cell discharges at a constant rate and has a useful life span of from three to four months, recorder calibration should be checked periodically. Continuous reference instruments do not, of course, require these periodic checks if the line voltage is of the proper value. Calibration should, however, be checked on all recorders whenever exact quantitative measurements are to be made.

Instructions for adjusting CALIBRATE control are found in Section 4.5.4.

2.3.4.4 SPAN and Gain Control Adjustments

Instructions for adjusting the SPAN and Gain controls are found in Section 4.

2.3.5 Condensed Operating Instructions

Condensed operating instructions are as follows:

(a) Check supply of chart paper and ink.

(b) Install pen; check ink flow(s).

(c) Connect line cord to appropriate a-c receptacle.

(d) Turn POWER switch ON.

(e) Connect signal source to input terminals.

(f) Connect event-marker actuating voltage to terminals 1 and 2 on rear of input chassis.

(g) Adjust chart-speed control(s) for desired chart speed.

(h) Adjust DAMPING control for proper damping.

(i) Place pen at desired zero position using ZERO ADJ. control.

(j) Record signal.

2.4 INSTRUMENT PERFORMANCE CHECKS

The performance of the recorder may be verified by the following procedures:

Damping:

(a) Short-circuit input terminals. Connect power cord to appropriate a-c receptacle.

(b) Turn POWER switch ON; adjust chart-speed control(s) for highest chart speed.

(c) Rotate DAMPING control to extreme clockwise position.

(d) Suddenly rotate ZERO ADJ. control. With proper damping, recording pen should move quickly to new balance position without overshoot. If overshoot occurs, rotate DAMPING control counterclockwise until overshoot just disappears.

(e) If recorder cannot be critically damped, consult Section 4.4.

Recording-Pen Velocity:

(a) Short-circuit input terminals. Connect power cord to appropriate a-c receptacle.

(b) Turn POWER switch ON; adjust chart-speed control(s) for lowest chart speed.

(c) Abruptly rotate ZERO ADJ. control to extreme clockwise position. Note velocity of pen travel.

(d) Abruptly rotate ZERO ADJ. control to extreme counterclockwise position. Note velocity of pen travel. The recording pen should move with a constant velocity (disregarding acceleration and deceleration) throughout the entire range of pen travel; the velocity should be approximately the same in either direction.

(e) If balance-motor speed is nonuniform, consult Section 4.4.

Dead-Band:

(a) Remove recorder chassis from case, as in Section 4.5.2.

(b) Short-circuit input terminals. Connect power cord to appropriate a-c receptacle.

(c) Turn POWER switch ON; adjust chart-speed control(s) for highest chart speed.

(d) Position recording pen in center of operating range using ZERO ADJ. control.

(e) Rotate DAMPING control to extreme clockwise position.

(f) Rotate balancing-motor sheave (largest pulley on top right side of recorder) so that recording pen moves off balance about 1 percent of recorder span. Gradually release sheave and note point on chart where recording pen comes to rest. This is illustrated at point A in Figure 8.

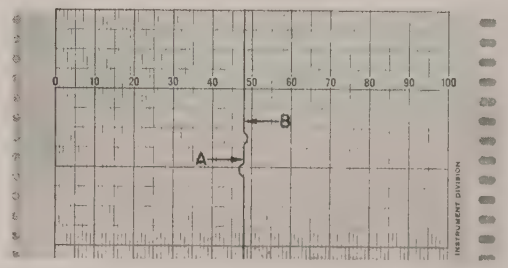


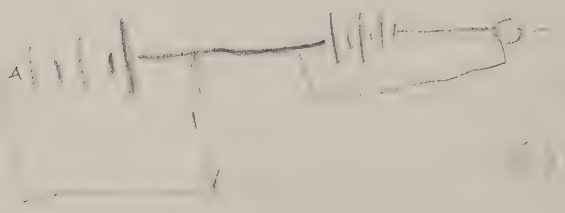
Figure 8 Recorder Dead-Band

(g) Rotate balancing-motor sheave to move recording pen 1 percent in other direction. Gradually release sheave and note new balance position. This is illustrated at point B in Figure 8.

(h) The displacement between the released positions noted in steps (e) and (f) should not exceed 1/2 percent of the recorder span. This is the dead-band defined in Section 1.6.1.

(i) If dead-band exceeds Data Sheet specification, consult Section 4.4.

theory of operation



3.0 THEORY OF OPERATION

3.1 INTRODUCTION

The Varian Model G-11A Strip-Chart Recorder is available with various types of input circuits. Since the characteristics of each type of input circuit are different, detailed explanations of the individual measuring circuits will be discussed in sections devoted exclusively to each type of input chassis. However, for the sake of continuity, the principle of operation of the recorder will be discussed with regard to the Type A1 Input Chassis.

3.2 D-C POTENTIOMETER MEASURING CIRCUIT

The potentiometer measuring circuits used in all input chassis of the Model G-11A Strip-Chart Recorder are calibrated, adjustable d-c voltage sources. This calibrated voltage, which is called the MEASURING VOLTAGE, is "matched against" the input SIGNAL VOLTAGE and the resultant voltage difference becomes the output ERROR SIGNAL. This is illustrated in Figure 9.

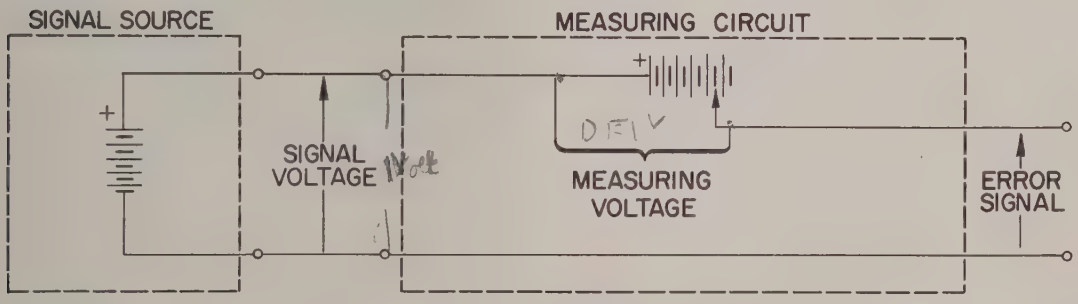


Figure 9 Analogous Measuring Circuit

If the MEASURING VOLTAGE is adjusted until it is exactly equal to the SIGNAL VOLTAGE, the ERROR SIGNAL becomes zero. This is "null-balance."

At null-balance, essentially no current flows through the input terminals; thus the apparent input resistance of the recorder approaches infinity. This extremely high input resistance virtually eliminates measurement errors due to internal source resistance or external lead resistance (provided, of course, that the combined source and lead resistances do not exceed recorder specifications). In effect, the recorder does not "load" the signal source.

The basic G-11A measuring circuit, as shown in Figure 10, is an electronic bridge with movable bridge terminals. The reference-cell current through the measuring slidewire produces a voltage across the slidewire. The voltage between slidewire points D and E, which is the MEASURING VOLTAGE, is applied to input terminals A and B. The circuit of Figure 10 is, in essence, the basic measuring circuit. The addition of the zero adjust voltage-divider makes the position of the movable slidewire contact dependent upon the position of the movable contact of the ZERO ADJ. control. In the G-11A recorder, the zero adjust voltage-divider allows the pen-zero position to be shifted continuously over the full span of the instrument; it also provides approximately 20 percent zero offset at either end of the span.

If the movable slidewire contact is positioned so that the measuring-circuit voltage across the input terminals is exactly equal to the input SIGNAL VOLTAGE, the output d-c ERROR SIGNAL is zero.

The actual measuring circuit of the Type A1 Input Chassis is shown in Figure 11; this is actually Figure 10 with the bridge rotated 90 degrees. The additional items permit rapid null-balancing, span and damping adjustments, and line-frequency filtering. Voltage-divider

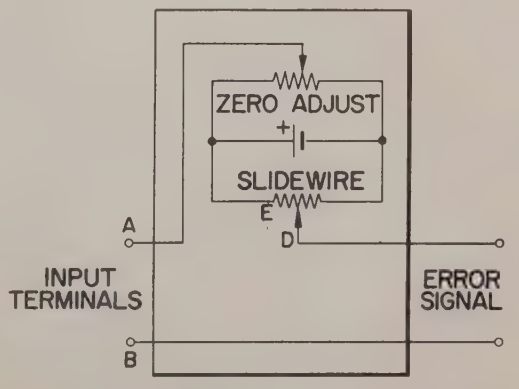


Figure 10 Basic G-11A Measuring Circuit

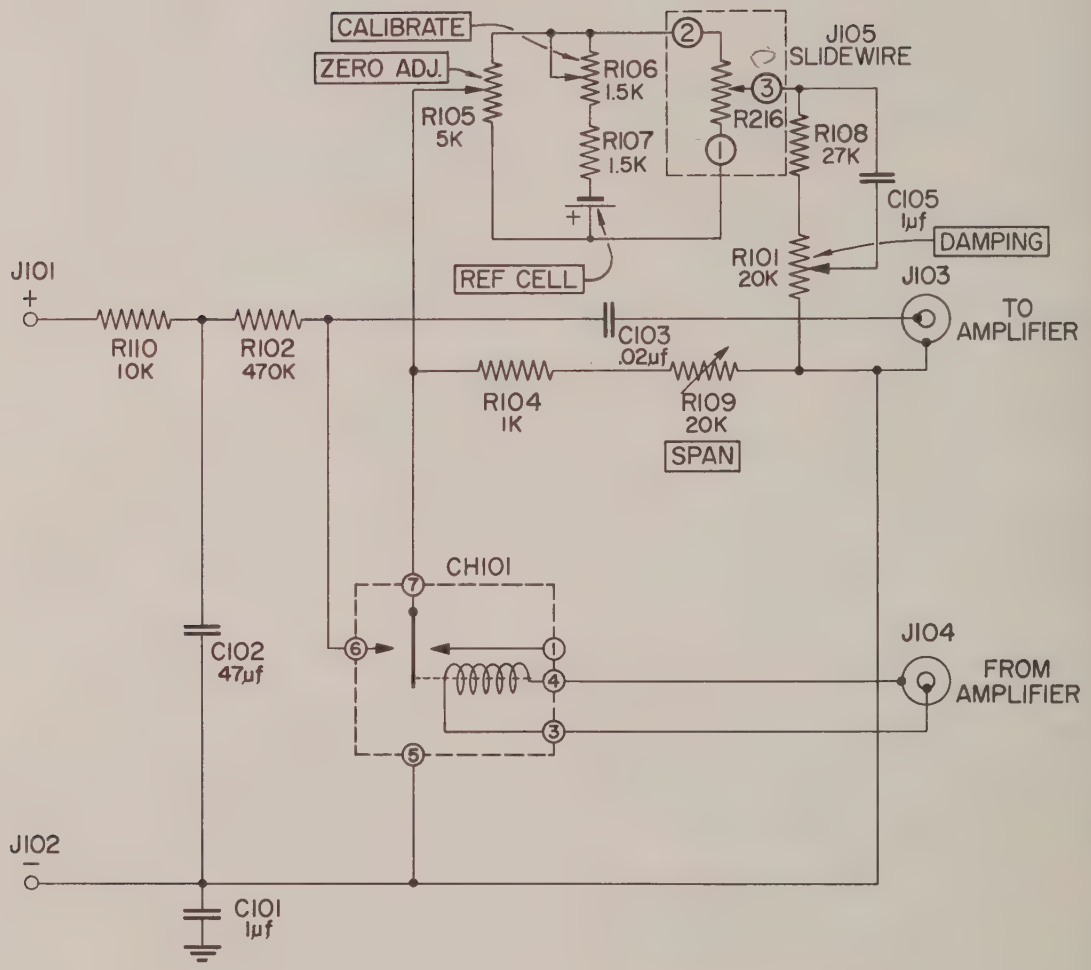


Figure 11 Actual G-11A Measuring Circuit (Type A1 Input Chassis)

networks R101-R108 and R104-R109 allow the measuring slidewire to be operated at a high level (approximately 1 volt) with respect to recorder span (100 millivolts or less). This virtually eliminates thermal emf's and noise generated at the slidewire contact.

If the recording system is at null-balance, the d-c ERROR SIGNAL is zero. If the system is not balanced, the amplitude of the ERROR SIGNAL is determined by the amount of unbalance and the polarity of the ERROR SIGNAL is determined by the direction of unbalance.

Operation of the potentiometer measuring circuit as an automatic null-balancing unit requires some method of null-detection; this is accomplished by the chopper-servo amplifier-balancing system.

3.2.1 Chopper

The chopper (CH101) converts the d-c ERROR SIGNAL to an alternating signal. This is necessary in order to amplify the ERROR SIGNAL with the required stability.

The chopper, which operates at the power-line frequency, has a 50-percent duty cycle; that is, the pin 6 and 7 contacts are open (or closed) about 50 percent of the time. When chopper contacts 6 and 7 are open, capacitor C103 charges up to a value which is equal to the SIGNAL VOLTAGE, and the voltage applied to the amplifier (across R217) is zero. When contacts 6 and 7 close, the MEASURING VOLTAGE, developed across resistors R104 and R109, is compared with the SIGNAL VOLTAGE across C103. If both voltages are equal (the system is at null-balance), the voltage applied to the amplifier will be zero. If, on the other hand, the MEASURING VOLTAGE differs from the SIGNAL VOLTAGE, the difference voltage will be applied to the amplifier as C103 either charges or discharges.

If the d-c ERROR SIGNAL is positive with respect to signal ground, the a-c signal from the chopper, known as the BALANCING SIGNAL, will be as shown in A of Figure 12. If the ERROR SIGNAL polarity is reversed, the BALANCING SIGNAL will be as shown in B of Figure 12 (180 degrees out-of-phase with A). Null-balance (or zero BALANCING SIGNAL) is shown in C of Figure 12.

Thus, the BALANCING SIGNAL has a peak-to-peak amplitude determined by the amplitude of the ERROR SIGNAL and a phase determined by the polarity of the ERROR SIGNAL.

3.3 TYPE A2 INPUT CHASSIS

The Type A2 Input Chassis provides an electronic Zener-diode reference system in

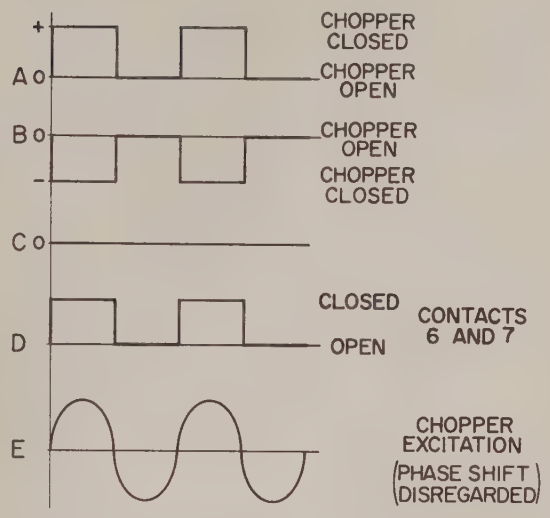


Figure 12 Chopper Operation

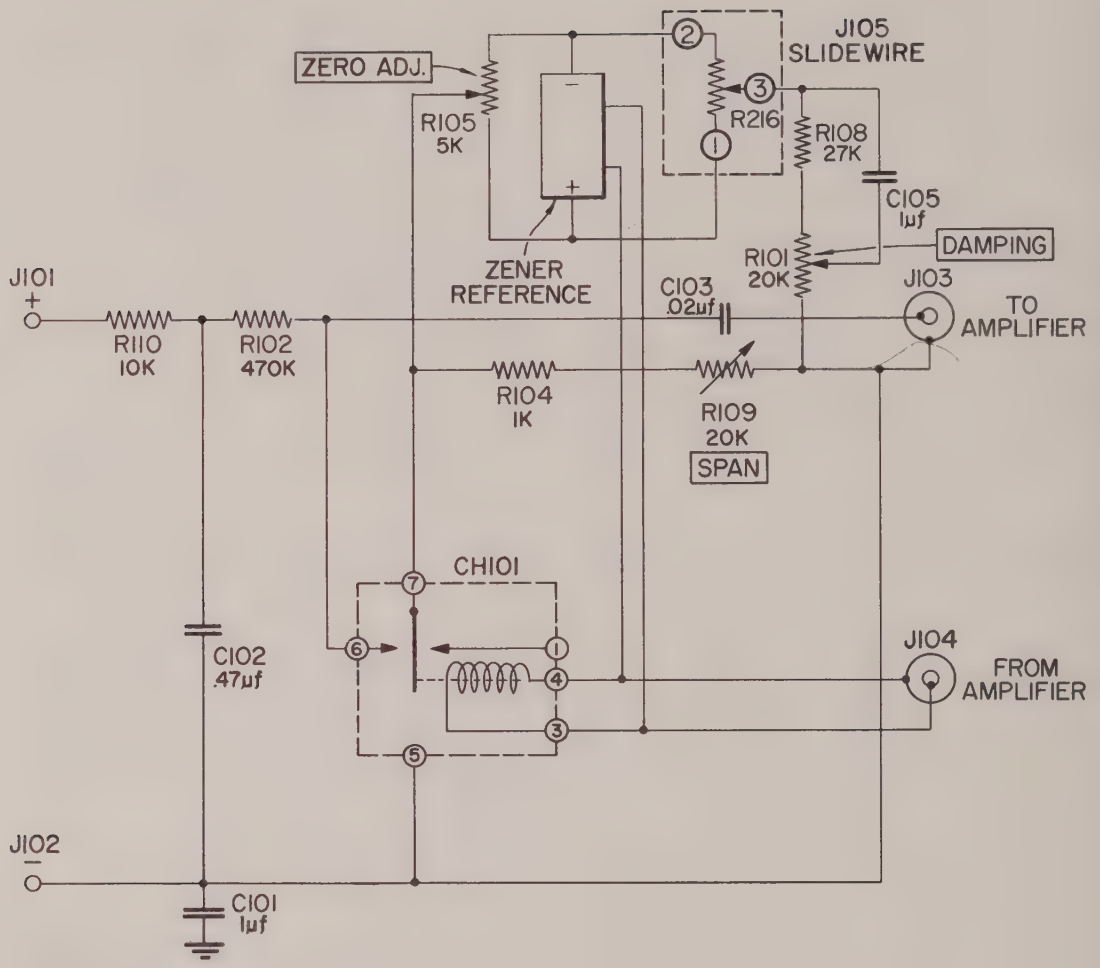
place of the mercury-cell system used in the A1 input chassis. The Zener reference system, which operates in the same manner as a conventional voltage regulator, provides a continuous source of reference voltage which does not require periodic replacement. The schematic diagram of the Zener-diode reference system is shown in Figure 13.

3.4 TYPE F1 INPUT CHASSIS

The Type F1 Input Chassis is designed for use with equipment having 1-milliampere, 1350-ohm output sources. The measuring circuit employed in the Type F1 Input Chassis is similar to the circuit employed in the A1 input chassis. Internal span of the F1 chassis is fixed; the span control is not used. The schematic for the type F1 chassis is shown in Figure 14.

Since indicating meters serve as low-pass filters, complete filtering of the output current is not required in equipment designed to use these indicating devices. However, the hum which is very often present in the output current of such equipment can produce serious difficulties in an a-c servo amplifier. For this reason, an additional R-C filtering network (R112, C104) has been added. This network provides the additional filtering which is often required.

Resistors R110 and R111 comprise the input circuit of the Type F1 Input Chassis. R110 acts as a dropping resistor and R111 samples the current to be measured and presents, to



Type A2 Input Chassis

Zener Reference Supply

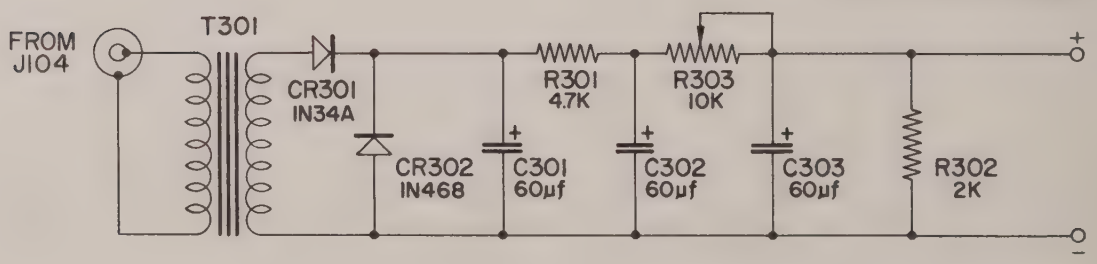


Figure 13 Schematic, Type A2 Input Chassis

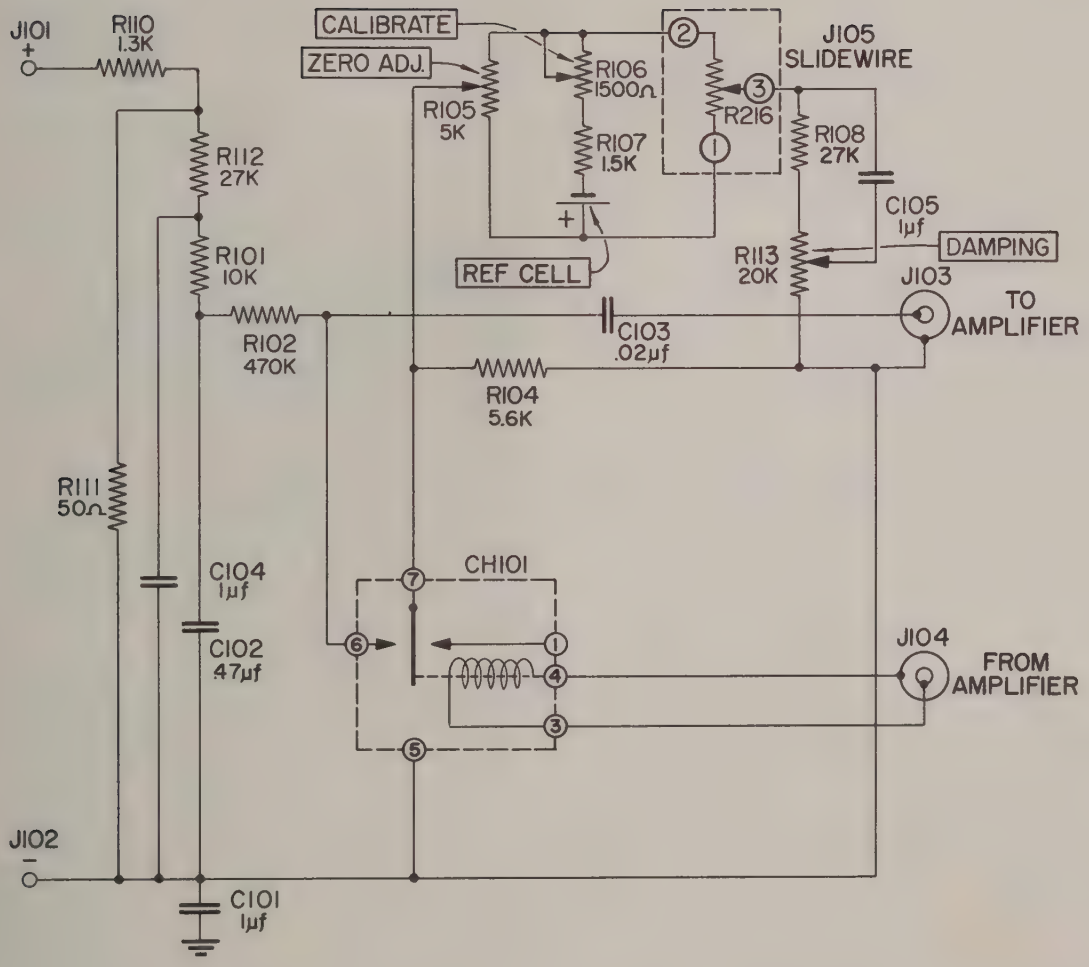


Figure 14 Schematic, Type F1 Input Chassis

the measuring circuit, a millivoltage which is directly proportional to the current flowing through it.

3.5 TYPE X1 INPUT CHASSIS

The Type X1 Input Chassis is a blank input chassis for incorporation of measuring circuits of the user's design. The X1 input chassis contains only the required circuit connectors.

3.6 SERVO AMPLIFIER AND POWER SUPPLY

The servo amplifier, consisting of V201, V202, and V203, is a narrow-band, R-C coupled amplifier. The power supply is a conventional full-wave rectifier with a capacitor-input filter.

The a-c BALANCING SIGNAL from the chopper, applied to the amplifier at P203, is amplified to a suitable power level. The amplified signal is then applied to the control winding of the balancing motor, where it interacts with the a-c line voltage applied to the reference winding.

Phase shift through the servo amplifier is adjusted by capacitors C204 and C208 so that the amplified BALANCING SIGNAL produces maximum balancing-motor torque for large input voltage changes (see Figure 15).

3.7 BALANCING SYSTEM

The balancing system, which consists of the balancing motor, the mechanical coupling, and the damping system, maintains the movable contact of the measuring slidewire at the null-balance point. The balancing motor provides the phase-sensing element, the mechanical coupling drives the measuring slidewire contact (and recording pen), and the damping system minimizes the effects of recorder inertia.

3.7.1 Balancing Motor

The balancing motor is a reversible, two-phase induction motor. One winding, known as the "line" (or reference) winding, is excited by the a-c power line; the other "control" winding is excited by the BALANCING SIGNAL from the amplifier. When the current in the control winding LEADS the current in the line winding by 90 degrees, the balancing motor rotates with maximum torque in one direction. If the control current LAGS the line current by 90 degrees, the balancing motor rotates in the opposite direction. However, for maximum balancing-motor torque, the voltages across the line and control windings are not in quadrature, but are approximately 40 degrees apart in phase. This is due to the differences in the resistive and inductive elements of each winding.

The balancing motor is a phase-sensitive device. Therefore, only control currents in quadrature with the line current cause rotation; noise or non-power-line frequencies do not cause rotation. These spurious components, which would be dissipated as heat in the motor, are minimized by the narrow bandpass of the amplifier.

When a change in the SIGNAL VOLTAGE occurs, the resulting amplified BALANCING SIGNAL causes the balancing motor to drive the measuring slidewire contact toward the null-balance point. With large signal changes, the balancing motor rotates at a fixed maximum speed of about 30 revolutions per minute; as the null-balance point is approached, the BALANCING SIGNAL decreases and the motor speed is reduced. When the null-balance point is reached, the BALANCING SIGNAL becomes zero and the motor ceases to rotate.

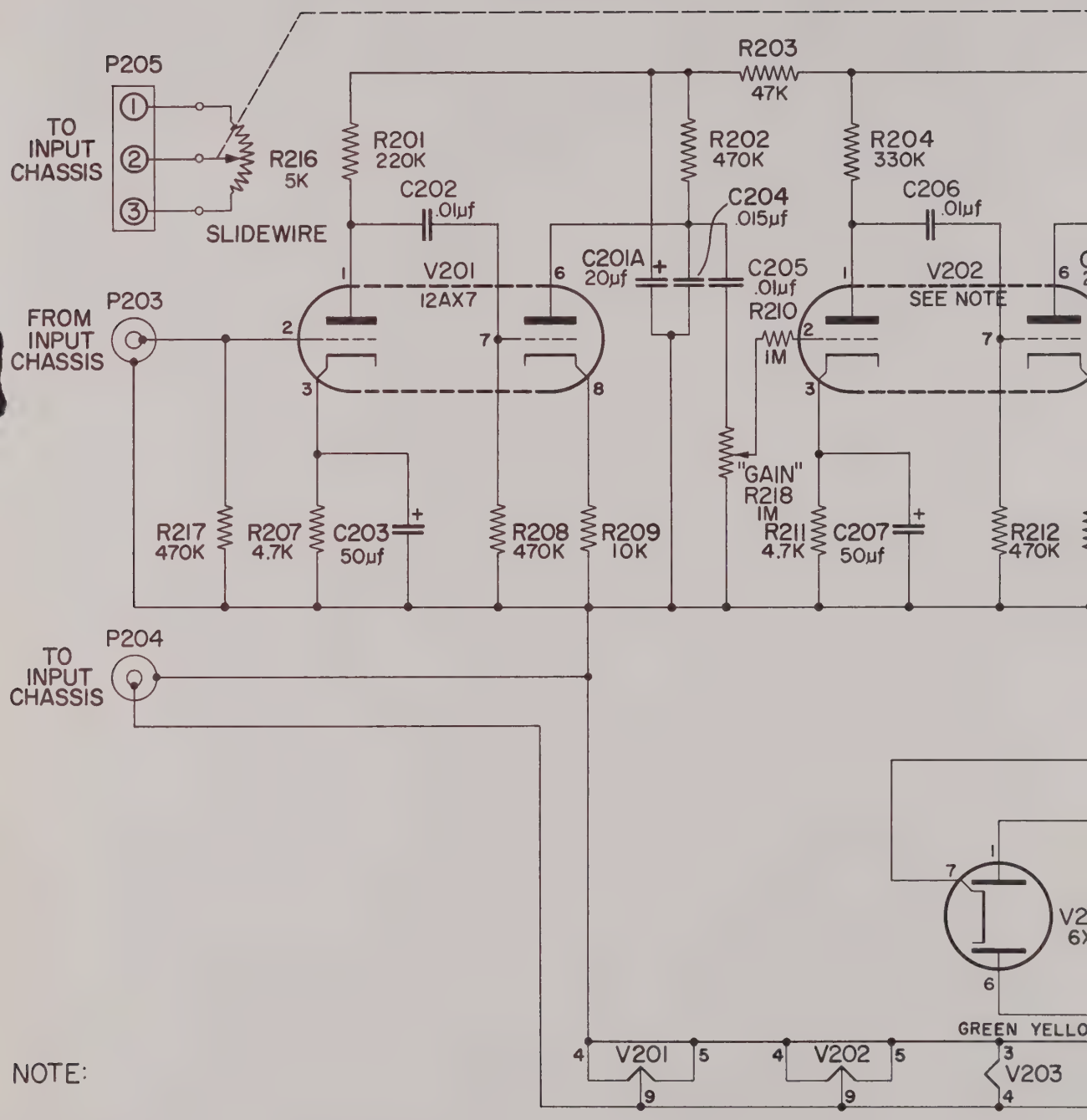
3.7.2 Damping System

The damping system counteracts the effects of inertia and thus prevents the recorder from presenting a false recording of the phenomena being investigated. The damping system consists of an R-C network in the input chassis (R101, R104, R108, R109, and C105).

When a change in the input voltage occurs, the damping voltage causes the system to accelerate very rapidly (about 0.1 seconds are required when a full-span step-function voltage is applied to the recorder) by increasing the apparent unbalance of the measuring circuit. Conversely, when the input voltage decreases, the damping voltage causes the system to decelerate very rapidly (about 0.05 seconds with the reduction of the full-span step-function voltage to zero) by producing a fictitious null condition in advance of the actual null. At the null-balance point, the damping voltage becomes zero, since the rate-of-change of the corresponding signal is also zero.

3.7.3 Mechanical Coupling Assembly

The mechanical coupling assembly, illustrated in Figure 16, links the balancing motor, the measuring slidewire, and the recording pen by a system of sheaves, idler pulleys, and a flexible drive cable. The flex-



NOTE:

FULL SPAN	V202
9-20MV	12AX7
21-50MV	12AT7
51-100MV	12AU7

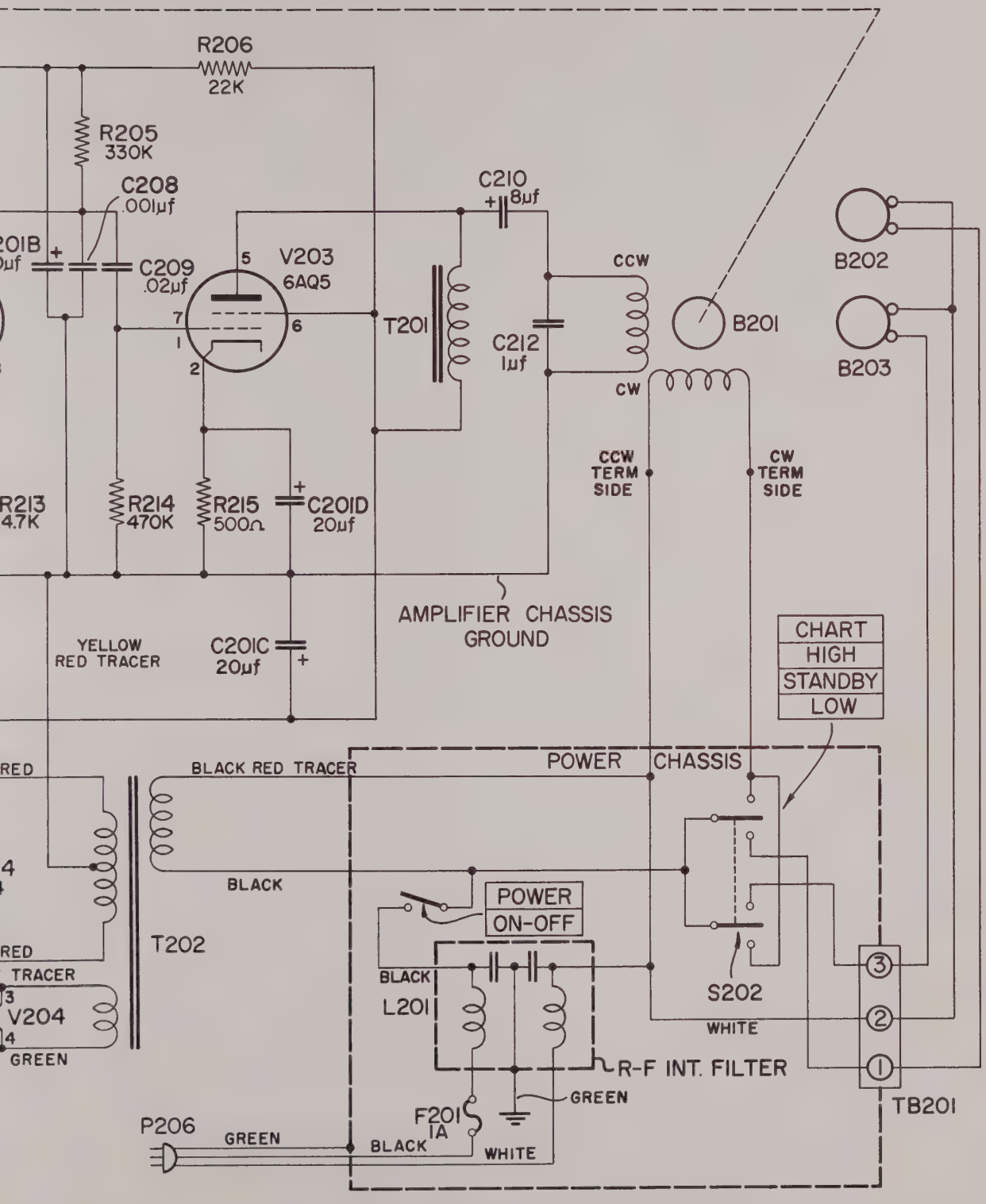


Figure 15 Schematic, Amplifier Chassis and Power Chassis

ible drive cable, which is attached securely to the sheaves and the pen carriage, is driven from the balancing-motor sheave. Since the balancing motor is connected to the balancing-motor sheave through a cork-disk clutch, there will be no damage if the balancing motor continues to operate after the recording pen has reached the extreme limits of its travel (the grip-ring stops shown in Figure 16). The larger spring on the pen carriage maintains the proper tension on the drive cable. The spring at the top of the balancing motor adjusts the amount of torque transmitted by the cork-disk clutch.

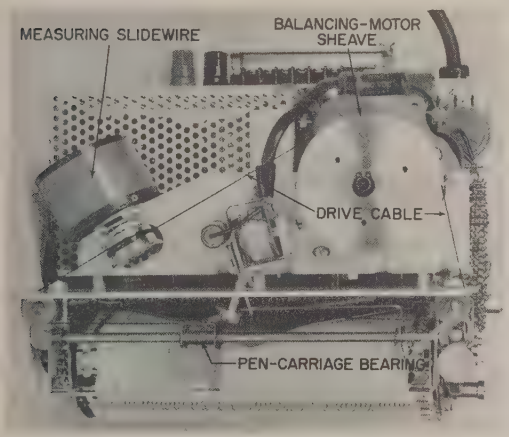


Figure 16 Mechanical Coupling Assembly

3.8 CHART-DRIVE SYSTEM

The chart-drive system consists of the chart-drive assembly, the chart take-up assembly, and the indicating pointer and recording pen. The chart-drive assembly consists of the single or dual chart-drive motors and either a direct-drive gear and ladder-chain arrangement, or a gear, ladder-chain, and speed-shifter arrangement. The chart take-up assembly consists of a gear and ladder-chain arrangement.

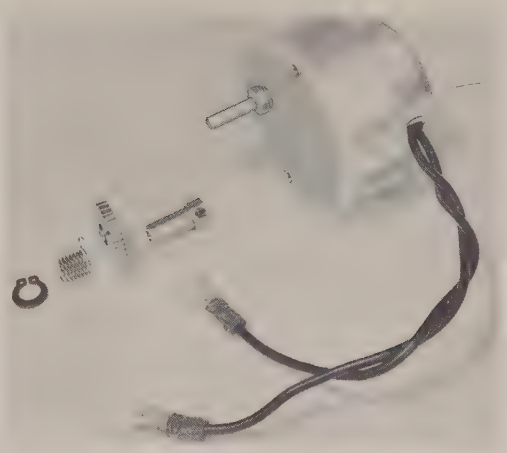


Figure 17 Chart-Motor Assembly

The chart-drive motor assembly, as shown in Figure 17, consists of a motor housing and shaft, a shaft collar, a gear and spring, and a grip ring. Chart motors for the slowest chart speeds have an additional gear train incorporated in the motor housing. Chart motors for the highest chart speeds, as illustrated in Figure 18, are two-phase motors and have an extra capacitor and resistor to shift the phase of the current through one of the windings.

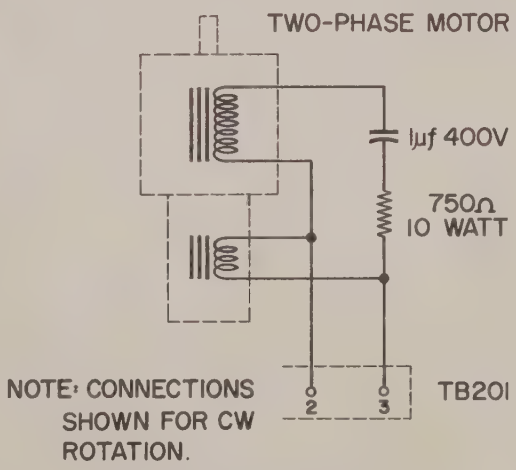


Figure 18 Schematic, High-Speed Chart Motor

service

4.0 SERVICE

4.1 WARRANTY

Varian Associates warrants the recorder products manufactured by the Instrument Division to be free from defects in material and workmanship. Liability under this warranty is limited to servicing or adjusting any instrument returned to the factory or designated service shop, for that purpose, and to replacing any defective parts thereof (except tubes, fuses and reference cells). This warranty is effective for one year after delivery of the recorder product to the original purchaser when (a) the recorder product is returned to the factory or designated service shop, transportation charges prepaid, and when (b) the recorder product is disclosed to Varian's (or the designated local representative's) satisfaction to be defective, through no fault of the user. If the malfunction has been caused by misuse or abnormal conditions of operation, repairs will be billed to the instrument owner. In this case, an estimate will be submitted before any work is begun.

4.2 FIELD AND FACTORY SERVICE

Field and factory service shops are maintained for the convenience of Varian instrument owners. If an instrument requires servicing, please contact the nearest representative or the factory. If the instrument is to be returned to the factory, shipping instructions may be obtained by writing to

Varian Associates
Recorder Service Manager
Instrument Division
611 Hansen Way
Palo Alto, California, USA

A list of factory representatives and/or distributors is contained in the flap on the rear cover of this instruction manual. On all correspondence please include the model and serial number of the instrument, a complete description of the malfunction, and all other pertinent information.

The Instrument Division has established the policy that every instrument returned for service will be completely checked in addition to correcting the cause of the malfunction. Each instrument shipped from the Service Department will be in "new instrument condition"; that is, each instrument will meet the specifications under which it was originally sold. When it appears that it will be unusually expensive to bring an instrument up to specification, the Service Department will contact the owner for specific instructions.

If a recorder becomes defective during the first two weeks after receipt of the instrument, the Warranty will be extended to cover all shipping costs.

4.3 PREVENTATIVE MAINTENANCE

4.3.1 Reference Cell

The mercury reference cell must be replaced periodically as its normal life expectancy is from three to four months. The 1.34-volt reference cell used in the G-11A recorder is discharging continuously. This eliminates battery surface charges (and the attendant reference-voltage fluctuations) and allows the recorder to be used immediately after normal tube warm-up time. As shown in Figure 19, the cell discharges at the rate of approximately 1/2 percent per month. This rate is nearly constant for the normal life of the cell; when the cell is exhausted, the reference voltage suddenly drops to an unusable value. Discharged reference cells are generally evidenced by the inability of the ZERO ADJ. control to move the recording pen from extreme positions.

Replacement reference cells are generally available from local electronics parts-supply houses under the designation Mercury "A" Batteries. (When purchasing reference cells specify Mallory RM-12R types.) Replacement cells are also available from the factory and from Varian recorder representatives.

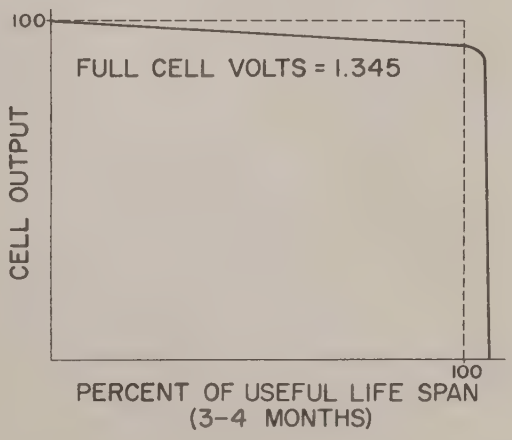


Figure 19 Reference-Cell Discharge Curve

4.3.2 Recording-Pen Care

The recording pen functions properly when ink reservoir and capillary tube are kept clean. If plastic reservoir cap is not installed, or if recording ink is allowed to dry in pen, the capillary tube may become obstructed and result in a temporary loss of the recorded variable.

The recording inks used with the G-11A recorder are water-soluble and ordinary tap water may be used for cleaning both capillary tube and ink reservoir. Difficult cleaning problems may require the use of hot soapy water, alcohol, or a commercial pen-cleaning fluid.

Check recording pen for cleanliness by filling the ink reservoir with water and exerting thumb pressure on the reservoir cap. If the capillary tube is unobstructed and the pen is clean, a stream of clear water will be forced out of pen point.

If pen point is obstructed, it may be necessary to use pen cleaner supplied with recorder. Insert pen cleaner in pen point and flush pen with water while moving cleaner in and out of pen point.

Never allow ink to dry in pen; the pen should be cleaned immediately after each recording. Minimize ink drying by keeping plastic reservoir cap in place when recording. Keep all metal parts of the recorder free from ink, since recorder inks can be corrosive.

4.3.3 Lubrication

All Model G-11A Recorders are equipped with ball-bearing balancing motors and should be lightly lubricated at three-month intervals or whenever the reference cell is replaced.

Do not lubricate Model G-11 Recorder balancing motors; these motors have bronze bearings and do not require additional lubrication.

All other points on both Model G-11 and G-11A Recorders should be lubricated semi-annually. Lubricants and lubrication points are tabulated in Table B and are shown in Figure 20.

The pen-carriage-rod bearing must never be lubricated, as this may effectively widen the dead zone and decrease the response time of the recorder; this bearing is a porous, self-lubricating type. Instead, the pen-carriage rod should be cleaned periodically with a clean, dry cloth; if necessary, remove residue on the rod with crocus cloth.

4.3.4 Amplifier Gain

The gain of the servo amplifier should be checked periodically and whenever exact quantitative measurements are to be made. Instructions for adjusting the gain are found in Section 4.5.7.

4.4 TROUBLE SHOOTING

The performance of the recorder may be checked by following the instructions in Section 2.4. If the recorder fails to meet specifications refer to Table C.

Figure 21 shows a capacitor-discharge record and illustrates the effects on the recorded variable of both a dirty measuring slidewire and a mechanical bind in the mechanical-coupling system.

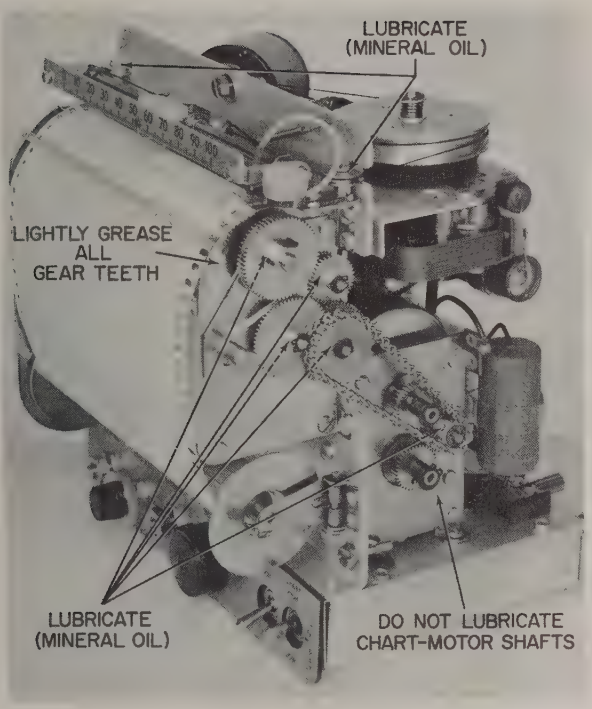
4.5 SERVICE INSTRUCTIONS

This section is devoted to specific instructions regarding the servicing or adjustment of the Model G-11A Recorder. Earlier Model G-11 Recorders may require some modifications to the instructions which will, in most cases, completely cover all G-11 series recorders.

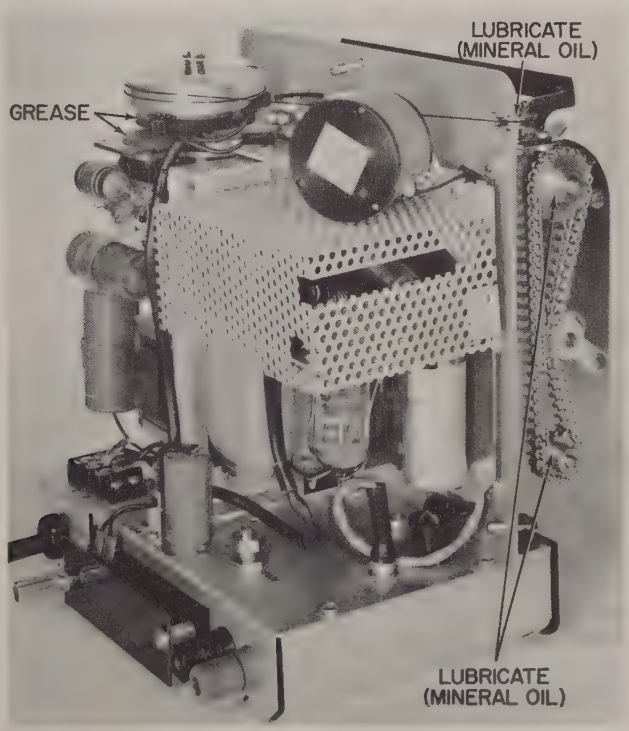
TABLE B G-11A TABLE OF LUBRICANTS

Part	Lubricant
Balancing-motor bearings	Light machine oil (1 or 2 drops)
Pen drive-cable idler pulleys	Mineral oil
Chart-drive gears	Lubriplate (type 110)
Bearings on chart-drive and take-up shafts	Mineral oil

WARNING: DO NOT LUBRICATE PEN-CARRIAGE-ROD BEARING.



Right-Front View of Recorder Chassis



Left-Rear View of Recorder Chassis

Figure 20 Lubrication Points

TABLE C TROUBLE SHOOTING

SYMPTOM	POSSIBLE CAUSE	REMEDY
Recorder fails to operate	F101 open; line cord not connected	Replace fuse
Chart paper does not advance	Speed shifter in N (neutral position); F101 open	Adjust shifter lever; replace F101
Chart paper binds; re-roll unbalanced	Paper catches on chart sprockets; re-roll improperly adjusted	Thread chart paper over chart retainer spring; re-attach chart paper or adjust re-roll
Intermittent chart-paper advance	Take-up chain loose; drive chain loose	Adjust chain tension
Pen moves to extreme limit of travel and balancing motor continues to operate	Low reference-cell voltage	Replace reference cell
	Chopper defective	Check chopper waveform; replace chopper
	Input open-circuited	Check continuity of input circuit
Instrument cannot be calibrated with CALIBRATE control	Low reference-cell voltage	Replace reference cell
Large dead-band, sluggish operation	Low amplifier gain	Adjust amplifier gain; check tubes for gain and noise
	Stray a-c pickup	Check grounding; shield signal cable
	Excessive source resistance	Reduce source resistance below maximum allowable value (see Data Sheet in rear cover)
	Low line voltage	Increase line voltage to 110-120v
	Chopper defective	Check chopper waveform; replace chopper
	Bind in mechanical system	Check mechanical system and eliminate bind
	Excessive drive-cable tension	Adjust cable tension
Nonuniform pen velocity	Bind in mechanical system (pen carriage binding on pen rod)	Eliminate bind (clean pen-carriage rod)
	Excessive drive-cable slack	Adjust cable tension
	Chopper defective	Check chopper waveform; replace chopper
Pen "hunts" at any position of DAMPING control	Excessive amplifier gain	Adjust gain
Repeated pen "jitter" at same point on chart	Dirty measuring slidewire	Replace or clean slidewire
Intermittent pen oscillation at various points on chart	V201 defective (microphonic)	Replace V201
Zero-voltage point drifts with line voltage change	V201 defective	Replace V201

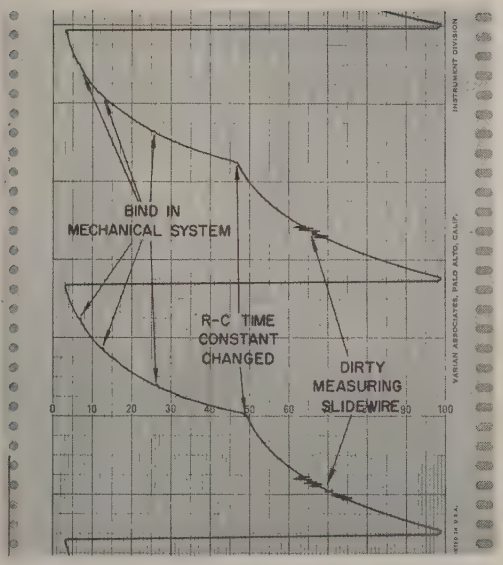


Figure 21 Resistance-Capacitance Discharge Curves

4.5.1 Reference-Cell Replacement

To replace reference cells, proceed as follows:

(a) Remove cap from REF CELL holder by unscrewing counterclockwise. Remove discharged reference cell.

(b) Insert new cell in holder with positive (+) end of cell facing cap. Replace cap.

4.5.2 Removal of Recorder Chassis from Case

Remove recorder chassis as follows:

DANGER

Operation of recorder outside of case should be performed with due regard for high voltages present at balancing motor, amplifier, and terminal strips.

(a) Disconnect line cord and remove connections to INPUT terminals.

(b) Remove instrument dust cover by depressing cover-release buttons on sides of cover and swinging bottom of cover forward and up.

(c) Completely loosen three captive screws at upper center and lower right- and left-hand corners of chassis (see Figure 22).

(d) Remove recorder chassis from case by sliding chassis forward and lifting out. Pass line cord through hole in right-rear corner of case.

(e) Reverse above procedure to install recorder chassis.

4.5.3 Input Chassis Removal

The Model G-11A Recorder is available with several types of input chassis. To replace an input chassis, proceed as follows:

(a) Remove recorder chassis from case (as in Section 4.5.2).

(b) Disconnect plugs from J203, J204, and J205.

(c) Remove input-chassis mounting screws accessible through holes in corners of chassis cover (see Figure 23).

(d) Remove input chassis from main chassis.

(e) Reverse above procedure to install input chassis.

4.5.4 Calibration

4.5.4.1 Type A1 Input Chassis

The mercury reference cell discharges at a nearly constant rate of 1/2 percent per month and has a service life of from

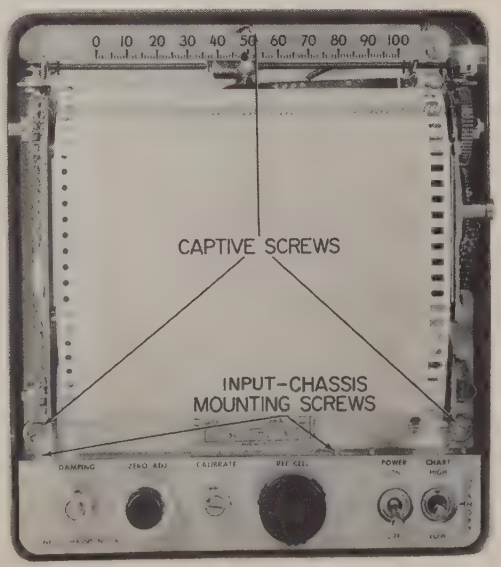


Figure 22 Recorder Chassis Removal

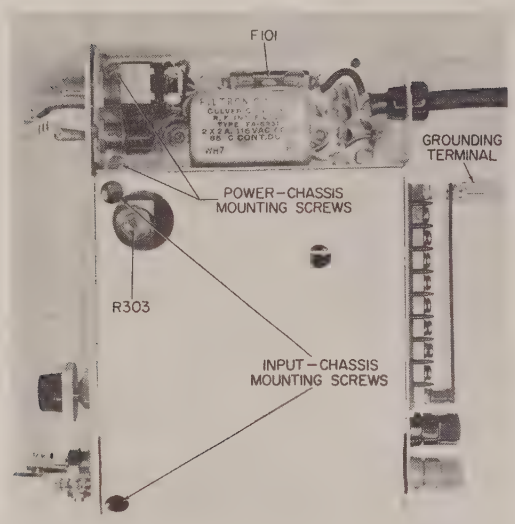


Figure 23 Input Chassis Removal

three to four months. Calibration should, therefore, be checked periodically and whenever exact quantitative measurements are to be made. To calibrate instruments equipped with Type A1 Input Chassis, proceed as follows:

(a) Short-circuit input terminals.

(b) Connect power cord to appropriate a-c receptacle.

(c) Turn POWER switch ON and allow one minute for instrument to warm up.

(d) Turn on CHART switch and place recording pen at zero position on chart paper using ZERO ADJ. control.

(e) Check indicating pointer and pen-point positions. If not aligned, loosen indicating-scale mounting screws and adjust until proper alignment is obtained. Tighten screws.

(f) Remove short-circuit and connect an accurately known voltage source (Leeds and Northrup 8657-C Portable Potentiometer or equivalent) to the recorder input terminals. The applied voltage may be equal to or less than the recorder's span; the source resistance must be less than the maximum permissible value for the recorder. If a portable potentiometer is used, the galvanometer should be locked or short-circuited so that emf's, generated by the movement of the galvanometer coil, will not affect the recorder. NOTE: See Section 4.5.4.4 for simple reference-cell calibration networks.

(g) Adjust CALIBRATE control until recording pen indicates exact value of input voltage.

(h) Remove calibrating source and record desired signal information.

4.5.4.2 Type A2 Input Chassis

Calibration of the Type A2 Input Chassis is the same as calibration for the A1 Input Chassis. However, since the A2 chassis Fine Calibrate control (R303) is accessible through a hole at the bottom of the input chassis, as shown in Figure 23, the recorder chassis must be removed from the case (as in Section 4.5.2).

4.5.4.3 Type F1 Input Chassis

Calibration of the Type F1 Input Chassis is the same as for the A1 Input Chassis with this exception: the calibration source should have a known constant-current of not more than 1.0 milliampere (the exact value of the source current determines the calibration point on the chart scale). A simple calibration source for the F1 Input Chassis, providing approximately 1 milliampere, consists of 10 reference cells in series with a 12K, 1 percent resistor.

4.5.4.4 Simple Calibration Source

A spare mercury reference cell may be used to obtain voltages of approximately 100, 50, 20, or 10 millivolts by using voltage-divider networks, as shown in Figure 24, having the following resistance values (all resistances are 1-percent precision types):

	100 mv	50 mv	20 mv	10 mv
R1	12.5K	13K	40K	40K
R2	1K	500 ohms	600 ohms	300 ohms

4.5.5 Recorder Span Adjustments

The adjustable-span feature allows the span of the recorder to be set at any value from 9 through 100 millivolts. The span is set

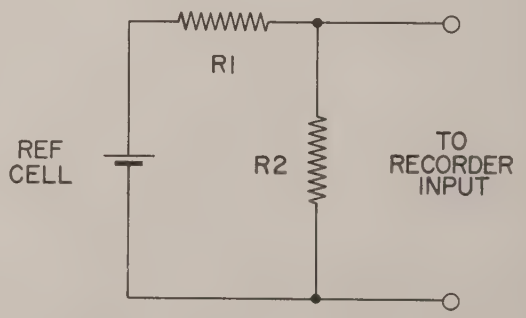


Figure 24 Simple Calibration Source

at the factory to the value specified at the time of purchase; if some other span is desired, the adjustment may be made as follows:

(a) Remove recorder chassis from case (as in Section 4.5.2). Place Model G-11 chassis on metal plate to simulate shielding effects of case.

(b) Short-circuit input terminals; rotate the DAMPING control to extreme clockwise position.

(c) Install proper tube type in V202. Consult Table D for required tube types.

TABLE D V202, TUBE TYPES

Span	Tube Types
9-20 mv	12AX7
21-50 mv	12AT7
51-100 mv	12AU7

(d) Place CALIBRATE control in center of range.

(e) Connect power cord to appropriate a-c receptacle and turn POWER switch ON.

(f) Place CHART switch (and speed shifter) in slowest chart-speed position(s).

(g) Place recording pen at zero position, using ZERO ADJ. control.

(h) Remove short-circuit and connect accurately known, adjustable voltage-source (Leeds and Northrup 8657-C Portable Potentiometer or equivalent) to input terminals.

(i) Adjust voltage source to desired span voltage.

(j) Unlock and rotate SPAN adjust control, located on top of input chassis, until recording pen shows approximately full-scale indication.

(k) Adjust GAIN control (as in steps (f) through (h), Section 4.5.7).

(l) Repeat steps (j) and (k) until gain is optimum for new span.

(m) Replace recorder in case.

(n) Adjust CALIBRATE control for exact indication of full-span voltage.

(o) Make suitable notation of new span value.

4.5.6 Tube Replacement

To replace any vacuum tube, proceed as follows (tube locations are shown in Figure 25):

(a) Remove recorder chassis from case (as in Section 4.5.2).

(b) Remove tube clamp(s) and/or metal shield and replace desired tube.

(c) Replace recorder chassis in case.

4.5.7 Amplifier Gain Adjustments

The gain of the servo amplifier is adjustable; this permits any span from 9 to 100 millivolts to be used and compensates for tube ageing. To adjust the gain of the amplifier, proceed as follows:

(a) Remove recorder chassis (as in Section 4.5.2). Place Model G-11 chassis on metal plate.

(b) Short-circuit input terminals; rotate the DAMPING control to extreme clockwise position.

(c) Verify insertion of proper tube type in V202 as tabulated in Table D (V201 is always 12AX7).

(d) Connect power cord to appropriate a-c receptacle and turn POWER switch ON.

(e) Place CHART switch (and speed shifter) in slowest chart-speed position(s).

(f) Rotate screwdriver-adjust GAIN control, located at lower right-rear corner of amplifier screen, to extreme clockwise position.

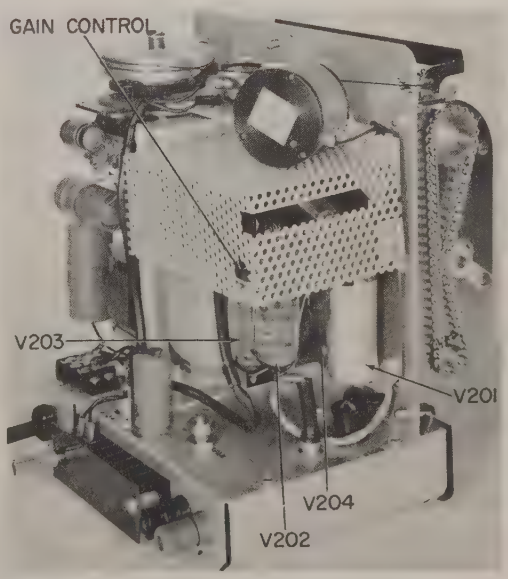


Figure 25 Tube Locations, Right-Rear View of Recorder

(g) Slightly rotate ZERO ADJ. control. Recording pen should now move in an oscillatory manner; if pen does not oscillate, check condition of V201, V202, and V203 and replace as necessary. If tubes are in good condition, check value of line voltage.

(h) With recording pen moving in an oscillatory manner, slowly adjust GAIN control in counterclockwise direction until oscillation ceases. Gain is now set at optimum value.

(i) Replace recorder chassis in case.

4.5.8 Chopper Checks

The electromechanical chopper used in the G-11A recorder operates on a 50-percent duty cycle; that is, the contacts are open (or closed) about half the time. To test or replace the chopper, proceed as follows:

(a) Remove recorder chassis from case (as in Section 4.5.2).

(b) Short-circuit input terminals.

(c) Connect power cord to appropriate a-c receptacle and turn POWER switch ON.

(d) Turn CHART switch on.

(e) Rotate ZERO ADJ. control so that recording pen moves to extreme right.

(f) Place CHART switch in STANDBY position and rotate ZERO ADJ. fully counterclockwise.

(g) Place "y-axis" leads from oscilloscope on chopper contacts 6 and 7. Adjust oscilloscope controls for display of two or three cycles of a-c BALANCING SIGNAL. Waveform should appear as in A of Figure 26.

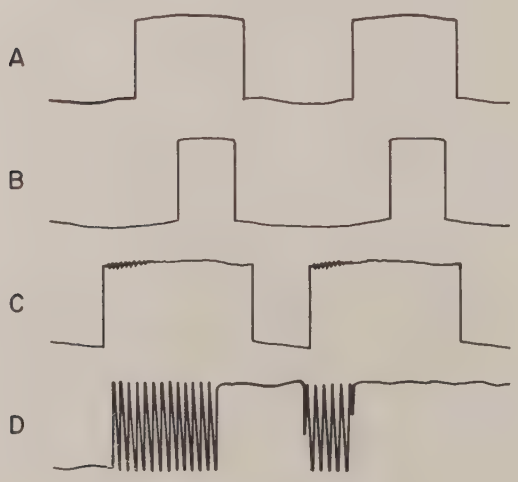


Figure 26 Chopper Waveforms

(h) Replace chopper if oscilloscope shows nonsymmetrical and/or noisy waveform as in B, C, or D of Figure 26.

(i) Replace chopper by loosening and rotating hold-down bracket and removing unit.

(j) Insert new chopper (Varian part number 901335) and observe waveform as in steps (g) and (h). If waveform is satisfactory, position and tighten chopper hold-down bracket. NOTE: Hold-down bracket is secured by nut within input chassis.

4.5.9 Event-Marker Adjustments

Pressure on the event-marker pen point is applied by the spring extending between the event-marker carriage link and the slot at the upper right side of the recorder chassis. Pressure on the event-marker pen should be such that the pen just maintains contact with the chart paper. To increase (or decrease) pen pressure, move the extension spring to the left (or right). To adjust the displacement of the pen, loosen the "relay" mounting screws and position the relay as desired; when making this adjustment, verify full-span position of recording pen. NOTE: Do not operate event marker repeatedly without advancing chart paper.

4.5.10 Pen Drive-Cable Adjustments

Small amounts of slack in the pen drive-cable may be removed by loosening the right-hand balancing-motor mounting screw (facing front of recorder) and shifting the position of the motor toward the rear of the recorder. For removal of excessive drive-cable slack retie cable to pen-carriage spring(s). If necessary, remove cable from tension spring, right-hand idler pulley, balancing-motor sheave and consult steps (k) through (q) in Section 4.5.11.

4.5.11 Pen Drive-Cable Installation

To install a new drive cable, proceed as follows (consult Figures 27 and 28 for parts nomenclature and locations):

(a) Remove recorder chassis from case (as in Section 4.5.2).

(b) Remove all old cable from recorder. Save springs on pen-carriage holder. Loosen right-hand balancing-motor mounting screw and fully insert screw in mounting slot. Tighten screw.

(c) With a section of drive cable at least 40 inches (1020 mm) long, make a loop approximately 12 inches (305 mm) from one end.

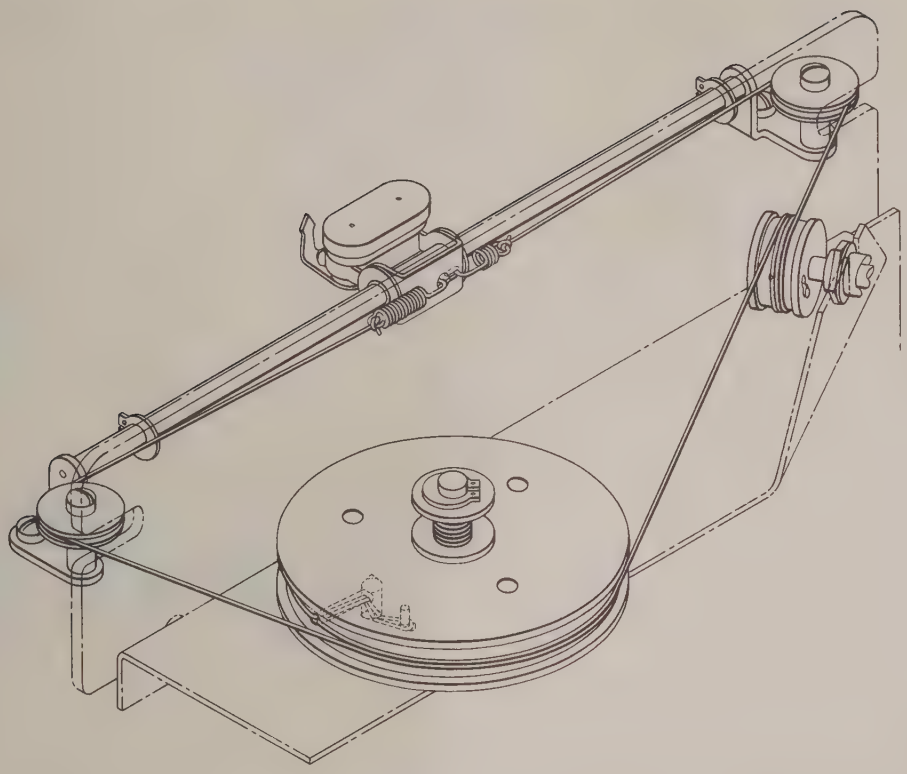


Figure 27 Balancing System, Pen Drive-Cable

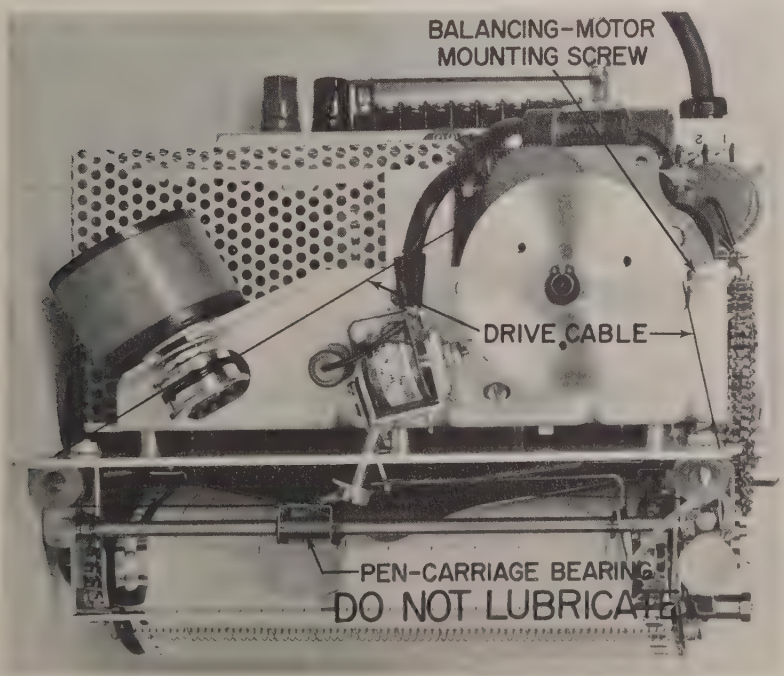


Figure 28 Balancing System, Top View of Recorder

(d) Crimp loop and insert it into "anchor-post" access hole on side of slidewire sheave and fasten loop over anchor-post on flat side of sheave. Pull both ends of cable to tighten loop around post.

(e) Rotate slidewire sheave to extreme clockwise position (facing front of recorder).

(f) Loosen slidewire-sheave mounting (Allen) screws and place anchor-post at highest vertical point. Tighten screws.

(g) Take short end of drive cable and make three counterclockwise turns around sheave progressing toward slidewire. Make certain cable is not twisted and does not overlap. Place tape over cable turns on sheave to prevent cable from unwinding.

(h) Move pen carriage to extreme left position. Place drive cable around left-hand idler pulley and slip cable through smaller spring at rear of pen carriage. Do not move sheave.

(i) Rotate slidewire sheave approximately 1/4 turn in counterclockwise direction (this places slidewire contact in most desirable operating range).

Hold slidewire sheave stationary and remove all slack between sheave and spring on pen carriage. Note point where cable engages spring.

(j) Remove spring and secure cable to spring at point noted in previous step; use a firm nonslip knot. Replace spring on pen carriage.

If cable is properly attached, clockwise rotation of slidewire sheave will not move sheave or pen carriage.

(k) Rotate balancing-motor sheave so "anchor-post" hole on side of sheave is at rear of recorder.

(l) Make loop in cable approximately 14 inches (355 mm) from slidewire sheave. Crimp loop and insert it through "anchor-post" hole; fasten loop to anchor post on bottom of sheave.

(m) Rotate balancing-motor sheave in clockwise direction (facing top of recorder) to wind excess cable around sheave. Place tape over cable turns. If cable is properly attached, "anchor-post" hole will again be at rear of recorder.

(n) Attach larger tension spring to slot in rear of pen carriage.

(o) Take loose end of cable, which should be below cable turns on sheave, and place cable around right-hand idler pulley. Attach cable to tension spring with firm nonslip knot.

(p) Proper cable tension is achieved when tension spring is directly in line with drive cable and parallel to pen-carriage rod.

(q) Remove tape from sheaves and check installation by placing recorder in operation and rotating ZERO ADJ. control. All balancing system components should move simultaneously throughout full range of travel.

4.5.12 Ladder-Chain Adjustments

4.5.12.1 Take-Up Chain

Tension on the take-up chain may be adjusted by proper positioning of the idler-pulley arm on the left side of the recorder. Take-up chain tension is determined by applying light finger pressure perpendicular to free length of chain. If chain moves more than 1/4-inch (6 mm), chain tension should be increased.

4.5.12.2 Chart-Drive Chain

Proper drive-chain tension is determined by applying light finger pressure perpendicular to free length of chain. If chain moves more than 1/8-inch (3 mm), remove excessive slack as follows:

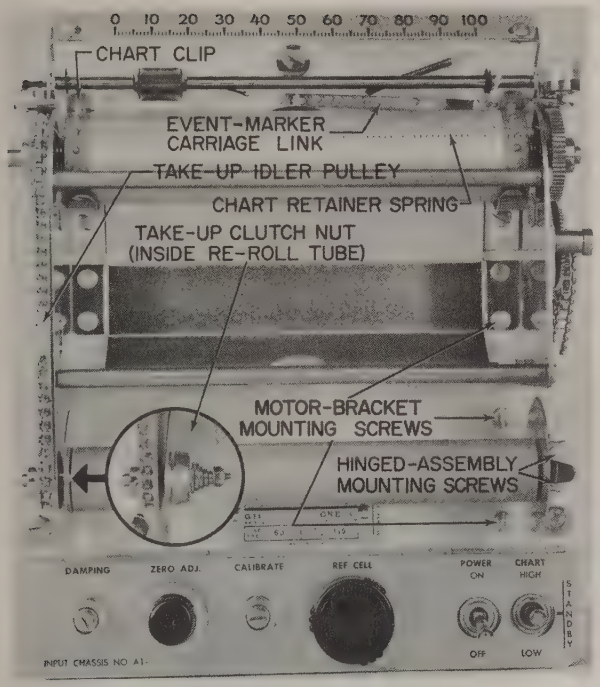
(a) Remove recorder chassis from case (as in Section 4.5.2).

(b) Remove chart paper from instrument.

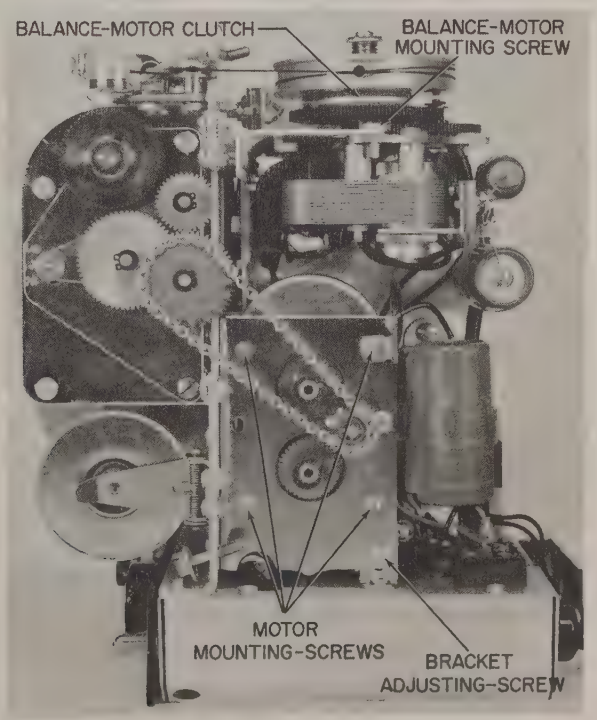
(c) Loosen 4 bracket screws (see Figure 29).

(d) To increase chain tension, pull chart-motor mounting bracket DOWN until proper chain tension is obtained; immediately tighten front-center mounting screw. Tighten three remaining screws (two in front, one in angle bracket in rear).

To decrease chain tension, pull chart-motor mounting bracket UP until proper chain tension is obtained; immediately tighten front-center mounting screw. Then tighten three remaining screws. NOTE: Previous model recorders have threaded spade bolt in place of angle bracket. To increase chain tension, loosen nut on top of power chassis, remove power-chassis cover and tighten lower spade-lug nut until desired tension is obtained. To decrease chain tension, reverse nut adjustments (tighten top nut; loosen bottom nut).



Front View of Recorder Chassis



Right-Side View of Recorder Chassis

Figure 29 Ladder-Chain and Chart Re-Roll Adjustments

4.5.13 Chart Re-Roll Adjustments

If chart paper has a tendency to pull at the sprocket teeth, thread chart paper over chart-retainer spring.

If take-up-clutch tension is improper, or chart paper re-roll is unbalanced, proceed as follows:

(a) Remove instrument front-cover.

(b) Remove re-roll tube by swinging re-roll tube release tab to right.

(c) To increase take-up clutch tension and re-roll chart paper tightly, hold left-hand take-up disk securely and tighten stop-nut on right-hand end of take-up shaft; check chart operation and repeat adjustment until desired operation is obtained.

To decrease take-up clutch tension and re-roll chart paper "loosely," hold left-hand take-up disk securely and loosen stop-nut on right-hand end of take-up shaft; check chart operation and repeat adjustment until desired operation is obtained.

To equalize chart-paper re-roll, remove recorder chassis from case (as in Section 4.5.2), loosen two screws holding hinged assembly on front-right side of recorder and adjust assembly as follows:

If tension is greater at right-hand side of chart paper, move assembly up and tighten screws; check chart operation and repeat adjustment until desired operation is obtained.

If tension is greater at left-hand side of chart paper, move assembly down and tighten screws; check chart operation and repeat adjustment until desired operation is obtained.

4.5.14 Chart-Speed Changes (or Additions)

The chart speed(s) of the recorder may be changed by replacing individual chart motor(s). Chart speed (in inches per minute or hour) is twice speed (in revolutions per minute or hour) stamped on chart-motor housing. Consult Figure 30 for parts nomenclature. To replace chart motor(s), proceed as follows:

(a) Disconnect power cord from a-c power line. Disconnect signal cables attached to input terminals.

(b) Remove recorder chassis from case.

(c) Disconnect chart-drive-motor terminals from terminal block TB201; higher speed motors are connected to terminals 2 and 3.

(d) Remove chart-motor-assembly mounting bracket by removing three screws in front panel and screw in vertical part of angle bracket. NOTE: Previous model recorders require removal of power-chassis cover and threaded spade lug used in place of angle bracket.

(e) Remove desired chart motor from mounting bracket by removing chart-motor mounting screws. NOTE: High-speed motors (chart speeds of 4 inches/minute or greater), which must always be installed in upper position on mounting bracket, require removal of resistor, capacitor and clamp, and associated terminal strip. High-speed motors cannot be installed in Model G-11 Recorders without extensive factory modification of the older recorder. Replacement motors suitable for Model G-11 Recorders are available from the factory.

(f) Install replacement chart motor on mounting bracket with screws removed in preceding step.

(g) Reverse above procedure to replace motor-assembly mounting bracket; connect higher speed motor to terminals 2 and 3 of TB201. (Make certain ladder chain is installed before attaching mounting bracket to recorder chassis.)

(h) Adjust ladder-chain tension as in Section 4.5.12.

4.5.15 Measuring-Slidewire Cleaning

The measuring slidewire (R216) is a precision element and should be handled with care while it is being cleaned. To clean the slidewire, proceed as follows:

(a) Remove recorder chassis from case (as in Section 4.5.2).

(b) Remove slidewire back-cover.

CAUTION

Hold cover against case while removing cover to prevent dropping slidewire wiper-arm contact spring located just inside cover.

On earlier model recorders metal taper pins were used in place of current screws and pin heads were cemented in the slidewire-cover recess. This cement must be removed first and taper pin heads extracted with a pointed object.

(c) Clean slidewire cap and wiper-arm contact spring with clean LINT-FREE material.

(d) Clean slidewire, using wooden match to insert clean lint-free material between slidewire and center post. Rotate cleaning material while turning slidewire wiper-arm with pulley sheave.

CAUTION

DO NOT remove wiper arm of slidewire.

DO NOT scratch or otherwise mar slidewire.

DO NOT use solvents for cleaning.

(e) Apply liberal quantity of lubricant (Lubriplate Type 110 or equivalent) to slidewire and wiper-arm contact spring.

(f) Reverse above procedure to reassemble slidewire.

4.5.16 Drive-Shaft External Coupling

The left-hand end of the chart-drive shaft is recommended for external coupling. The chart-drive shaft is 1/4-inch (approximately 6.3 mm) in diameter. It is recommended that a rigid coupling be used. NOTE: Chart-drive shaft revolves one revolution per 4 inches (approximately 102 mm) of chart-paper travel.

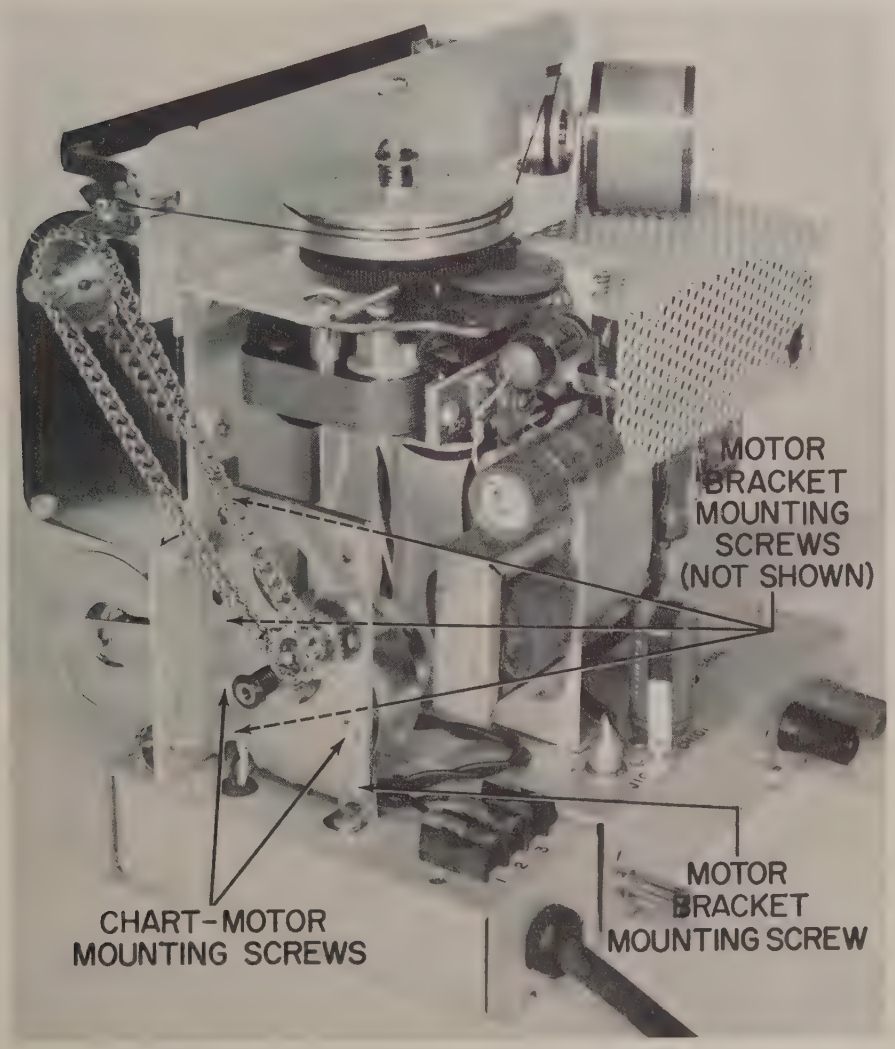


Figure 30 Chart Motor Addition or Replacement, Basic Recorder

parts list

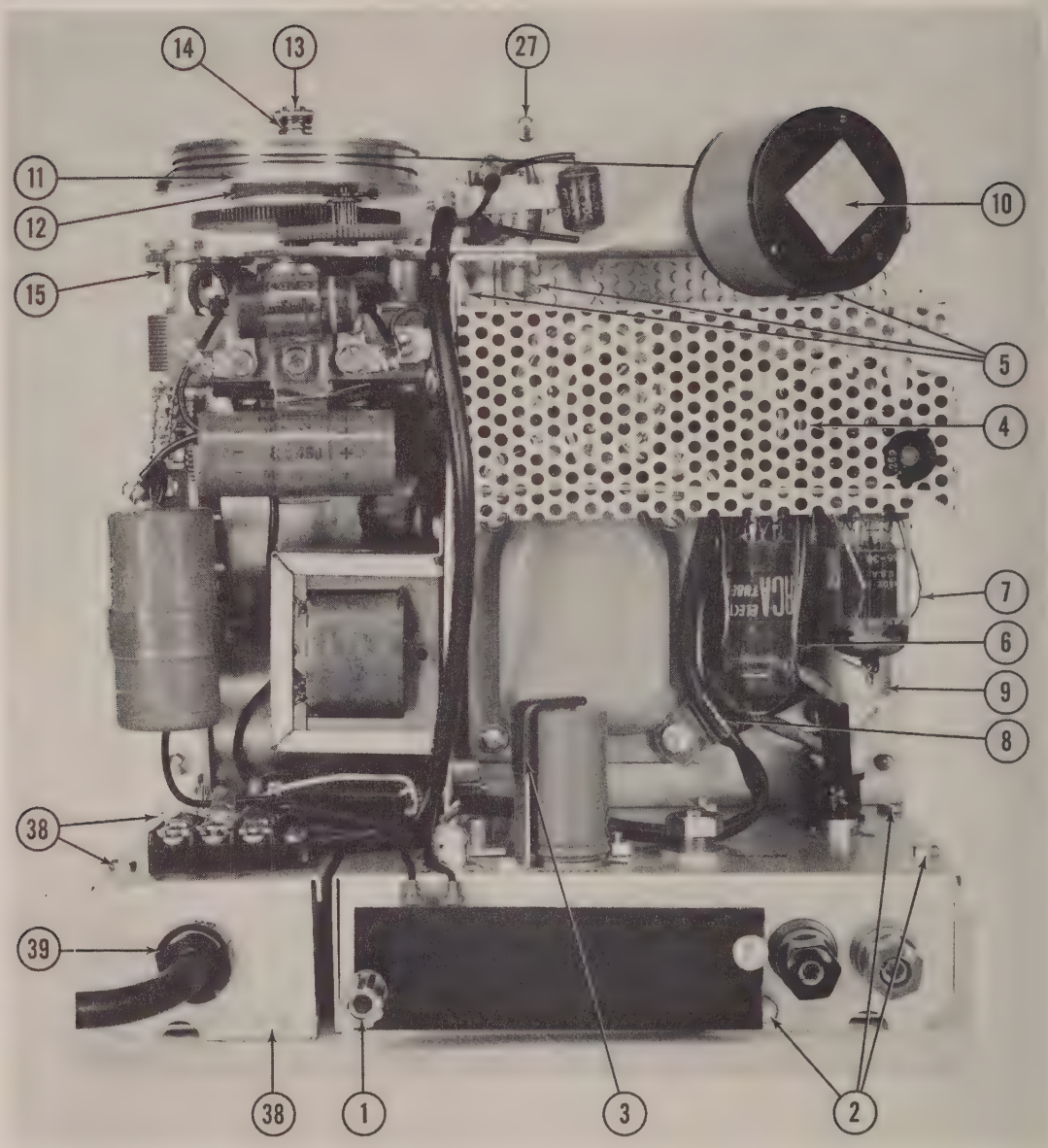


Figure 31 Mechanical Parts List

MECHANICAL PARTS LIST

Figure Reference	Part	Description	Varian Part No.
Input Chassis: (see Figure 31)			
	Ring	Locking, zero-adjust	22-899 980
	Knob	Zero-adjust	23-519 990
	Holder	Reference-cell (cap not included)	901038
	Holder	Reference-cell (cap included)	902034
	Cap	Reference-cell holder	901043
1	Connector	Binding-post (grounding)	901515-02
	Screw	Machine, input-chassis mounting (2 required)	6-32 x 5/16 B.Hd.
	Cover	Chassis (specify position of R303)	
2	Screw	Sheet-metal, chassis-cover (6 required)	#6 x 1/4 Hex.Hd.
3	Assembly	Chopper-clamp	902016
Amplifier Chassis: (see Figure 31)			
4	Assembly	Amplifier-cover	902379
5	Screw	Machine, amplifier-screen mounting (3 required)	6-32 x 5/16 B.Hd.
	Nut	Steel (1 required)	6-32 Hex.
6	Clamp	Tube, wire (for V203,V204)	22-149 913
7	Clamp	Tube, wire (for V202)	22-149 912
8	Clamp	Cable, for P204	22-119 803
9	Shield	Electron-tube, aluminum (for V201). Do not use steel.	24-282 960
Servo Chassis: (see Figure 31)			
10	Assembly	Sheave, measuring-slidewire	900756
	Screw	Set, for 900756 above (2 required)	4-40 x 1/8 Soc.Hd.
11	Assembly	Sheave, balancing-motor	901711
	Screw	Set, for 901711 above (2 required)	4-40 x 1/8 Soc.Hd.
12	Disk	Clutch (2 required)	901707
	Disk	Clutch (1 required)	901708-01
13	Shaft	Extension, balancing-motor	901717
	Pin	Drive, for 901717 above	19-224 990
14	Spring	Clutch, balancing-motor	901709
	Washer	Flat, for 901709 above (2 required)	14-121 114

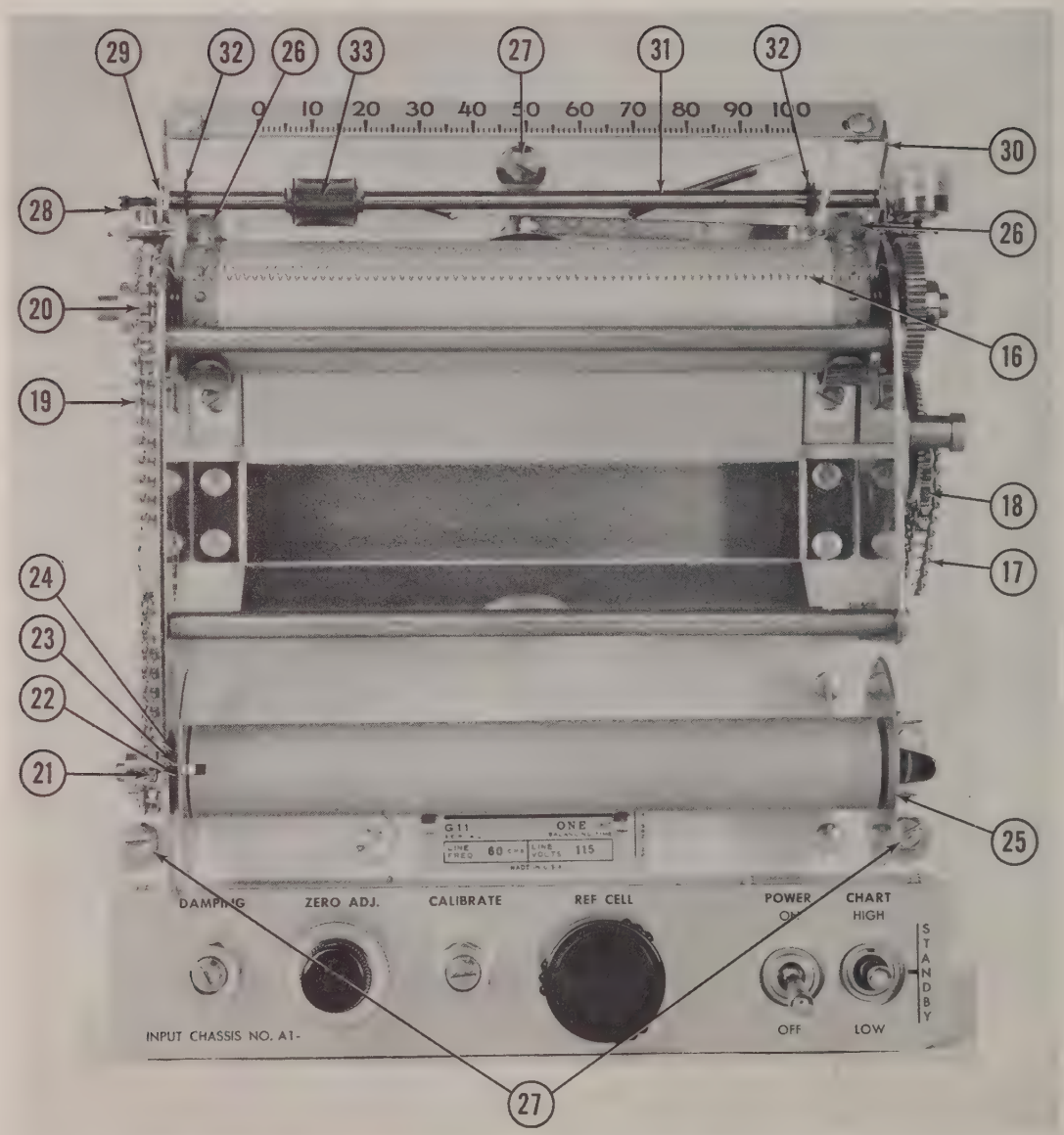


Figure 32 Mechanical Parts List

MECHANICAL PARTS LIST (cont)

Figure Reference	Part	Description	Varian Part No.
	Ring	Retainer, for 901709 above	22-678 944
15	Screw	Machine, balancing-motor mounting	8-32 x 5/16 B.Hd.
	Assembly	Pen drive cable (including 901654 spring)	901121-02
	Spring	Drive cable	901654
Chart-Drive Assembly: (see Figure 32)			
16	Spring	Chart-retainer	901616
	Sprocket	Chart-drive, for instruments without speed-shifter	900991
	Screw	Set, for 900991 above	6-32 x 1/8 Soc.Hd.
	Chain	Chart-drive, for instruments without speed-shifter	901327-02
17	Chain	Chart-drive, for instruments with speed-shifter	901327-03
18	Sprocket	Chart-drive, for instruments with speed-shifter	901123
	Screw	Set, for 901123 above	6-32 x 1/8 Soc.Hd.
19	Chain	Chart take-up	901327-01
20	Sprocket	Drive, for chart take-up unit	900991
	Screw	Set, for 900991 above	6-32 x 1/8 Soc.Hd.
	Bearing	Chart-drum shaft (2 required)	23-139 805
	Ring	Retainer, for left-hand bearing above	22-678 837
21	Sprocket	Driven, for chart take-up unit	900992
	Screw	Set, for 900992 above	6-32 x 1/8 Soc.Hd.
	Bearing	Take-up (1 required)	23-139 804
	Ring	Retainer, for above bearing	22-678 831
	Spacer	Bearing	901024
	Spacer	Clutch	901460
22	Assembly	Take-up clutch	900966
	Washer	Flat, brass	14-104 004
23	Spring	Take-up clutch	21-719 930
	Washer	Flat, brass	14-134 010
24	Nut	Elastic stop, 4-40 Hex.	13-501 104
	Tube	Re-roll	901279
25	Assembly	Hinged-center	901097
	Spring	Hinge (included in 901097 above)	900957

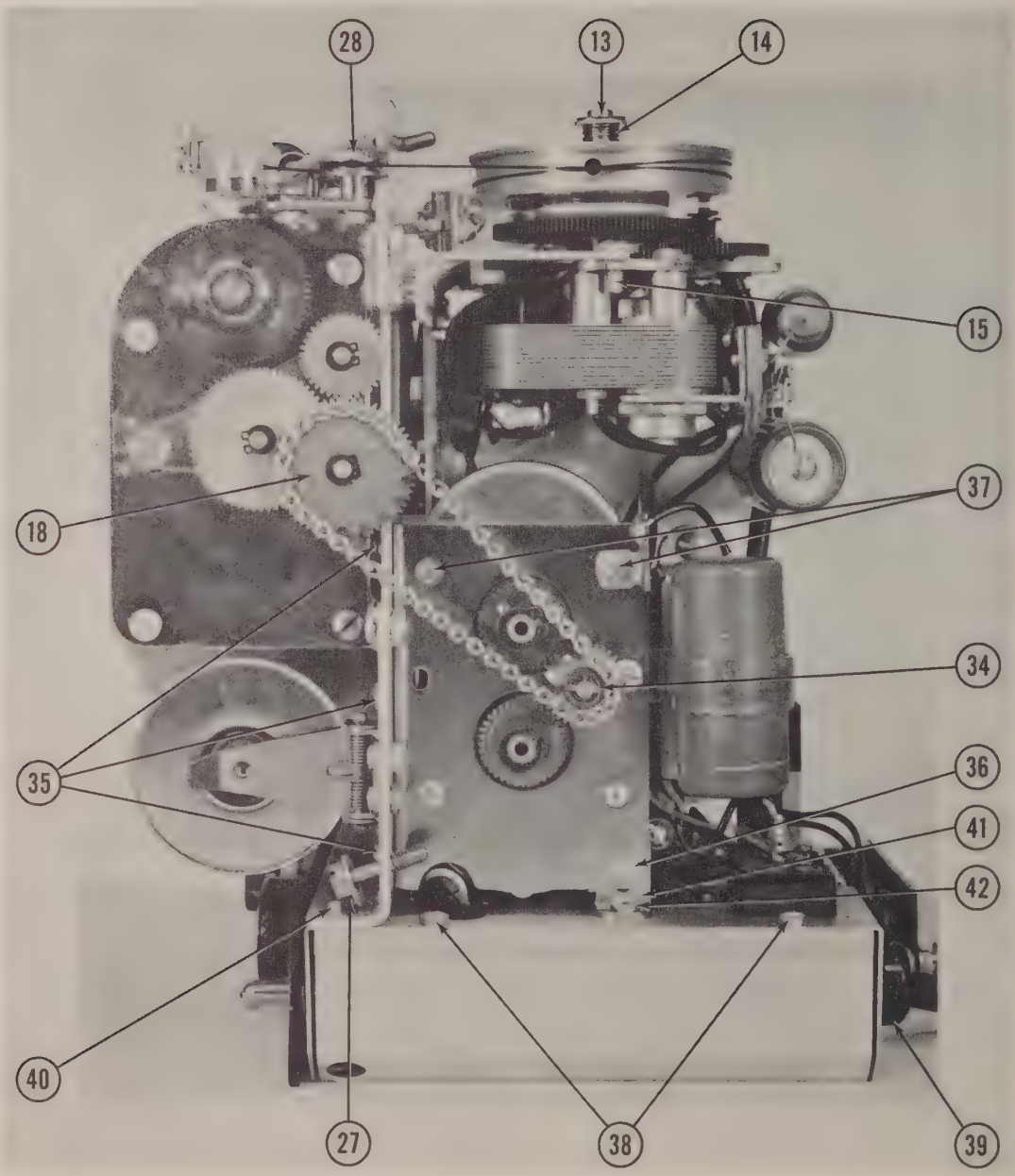


Figure 33 Mechanical Parts List

MECHANICAL PARTS LIST (cont)

Figure Reference	Part	Description	Varian Part No.
	Screw	Machine, for 901097 above (2 required)	4-40 x 5/16 B.Hd.
	Nut	Steel, for 901097 above	4-40 Hex.
	Platen	(Chart compartment cover)	900999
26	Clip	Chart hold-down (2 required)	900998
	Screw	Machine, for 900998 above	6-32 x 3/16 B.Hd.
27	Screw	Captive, for securing recorder to case (3 required)	901326
28	Pulley	Idler, for pen drive cable (2 required)	901028
	Screw	Shoulder, for 901028 above (2 required)	901027
	Washer	Lock, for 901027 above	#4 Int. Tooth
	Nut	Steel, for 901027 above	4-40 Hex.
	Bracket	Mounting, for pen-carriage rod (RH)	900964-01
29	Bracket	Mounting, for pen-carriage rod (LH)	900964-02
	Screw	Machine, for 900964 above	4-40 x 1/4 B.Hd.
	Nut	Steel, for 900964 above	4-40 Hex.
	Bracket	Indicating-scale, LH	901167-02
30	Bracket	Indicating-scale, RH	901167-01
	Screw	Machine, for 901167 above	4-40 x 3/16 B.Hd.
31	Rod	Pen-carriage	900961
32	Ring	Retainer, for 900961 above (2 required)	22-678 930
	Assembly	Pen-carriage	901165
33	Bearing	Pen-carriage	902498
	Carriage	Recording-pen	900970
	Ring	Retainer, pen-carriage (2 required)	22-678 825
Drive-Motor Assembly: (see Figure 33)			
34	Gear	Idler, chart-drive	901125
	Ring	Retainer, for 901125 above	22-678 815
(see Fig 17)	Assembly	Gear, chart-motor (does not include motor)	901128
	Spring	Torsion, for 901128 above	901127
	Ring	Retainer, for 901128 above	22-678 944
	Bushing	Drive-motor shaft, for 901128 above	901124

MECHANICAL PARTS LIST (cont)

Figure Reference	Part	Description	Varian Part No.
	Screw	Set, for 901124 above	4-40 x 1/8 Soc.Hd.
35	Screw	Machine, for chart-motor mounting bracket	6-32 x 3/16 B.Hd.
36	Screw	Machine, for securing angle bracket to motor bracket	4-40 x 1/4 B.Hd.
	Washer	Lock	#4 Int. Tooth
	Nut	Steel	4-40 Hex.
37	Screw	Machine, for attaching chart motor to mounting bracket	4-40 x 1-inch B.Hd.
	Washer	Lock	#4 Int. Tooth
	Nut	Steel	4-40 Hex.
Power Chassis: (see Figure 33)			
	Cover	Chassis	940952
38	Screw	Sheet-metal, cover mounting (3 required)	#6 x 1/4 Hex.Hd.
39	Bushing	Strain-relief	22-799 966
40	Screw	Machine, power-chassis mounting (2 required)	6-32 x 1/4 B.Hd.
41	Bracket	Angle	902305
42	Screw	Machine, for 902305 above	6-32 x 7/16 B.Hd.
	Washer	Lock	#6 Int. Tooth
	Nut	Steel	6-32 Hex.
	Nut	Keps, for chart-motor brackets with spade bolt (2 required)	6-32 Keps

ELECTRICAL PARTS LIST

Schematic Reference	Part	Description	Varian Part No.
Input Chassis (unless noted, part applies to all chassis):			
BT101 (not A2)	Battery	Mercury reference cell (Mallory RM-12R)	74-101 550
C101	Capacitor	Fixed, mylar, 1-μf, 200v	41-729 897
C102	Capacitor	Fixed, mylar, 0.47-μf, 200v	41-719 886
C103	Capacitor	Fixed, paper, 0.02-μf, 400v	41-346 852
C104 (F1)	Capacitor	Fixed, mylar, 1-μf, 200v	41-729 897
C105	Capacitor	Fixed, mylar, 1-μf, 200v	41-729 897
C301, C302, C303 (A2)	Capacitor	Fixed, electrolytic, 60-μf, 6v	41-506 231
CR301 (A2)	Diode	Type 1N34A	66-398 990
CR302 (A2)	Diode	Type 1N468	66-397 943
CH101	Chopper		901335
J101	Connector	Binding-post, red	51-799 999
J102	Connector	Binding-post, black	51-799 990
J103, J104	Connector	Receptacle	51-471 980
J105	Connector	Receptacle	54-233 990
	Connector	Binding-post, grounding	901515-02
		NOTE: Only connectors are supplied with Type X1 Input Chassis	
R101	Resistor	Variable, wire-wound, 20K, 2w	37-586 520
R101 (F1)	Resistor	Fixed, composition, 10K, 1/2w, 10%	32-202 510
R102	Resistor	Fixed, composition, 470K, 1/2w, 10%	32-202 647
R103		Deleted	
R104	Resistor	Fixed, composition, 1K, 1/2w, 10%	31-688 410
R104 (F1)	Resistor	Fixed, composition, 5.6K, 1/2w, 1%	31-688 456
R105	Resistor	Variable, composition, 5K, 2w	36-895 450
R106 (not A2)	Resistor	Variable, wire-wound, 1.5K, 2w	37-586 415

ELECTRICAL PARTS LIST (cont)

Schematic Reference	Part	Description	Varian Part No.
R107 (not A2)	Resistor	Fixed, composition, 1.5K, 1/2w, 1%	31-688 415
R108	Resistor	Fixed, composition, 27K, 1/2w, 1%	31-688 527
R109 (not F1)	Resistor	Variable, wire-wound, 20K, 2w	37-586 520
R110	Resistor	Fixed, composition, 10K, 1/2w, 10%	32-202 510
R110 (F1)	Resistor	Fixed, composition, 1.3K, 1/2w, 1%	31-688 413
R111 (F1)	Resistor	Fixed, composition, 50-ohm, 1/2w, 1%	31-688 250
R112 (F1)	Resistor	Fixed, composition, 27K, 1/2w, 10%	31-202 527
R113 (F1)	Resistor	Variable, wire-wound, 20K, 2w	37-586 520
R301 (A2)	Resistor	Fixed, composition, 4.7K, 1/2w, 1%	31-686 447
R302 (A2)	Resistor	Fixed, composition, 2K, 1/2w, 1%	31-686 420
R303 (A2)	Resistor	Variable, wire-wound, 10K, 2w	37-586 510
T301 (A2)	Transfmr	Zener supply	901723
Amplifier:			
C201A, C201B, C201C, C201D	Capacitor	Fixed, electrolytic, 20-20-20-μf, 400v, 20-μf, 25v	41-548 427
C202	Capacitor	Fixed, paper, 0.01-μf, 400v	41-346 844
C203	Capacitor	Fixed, electrolytic, 50-μf, 6v	41-508 816
C204	Capacitor	Fixed, paper, 0.015-μf, 400v	41-346 911
C205, C206	Capacitor	Fixed, paper, 0.01-μf, 400v	41-346 844
C207	Capacitor	Fixed, electrolytic, 50-μf, 6v	41-508 816
C208	Capacitor	Fixed, paper, 0.001-μf, 400v	41-346 800
C209	Capacitor	Fixed, paper, 0.02-μf, 400v	41-346 852
P203, P204	Connector	Plug	51-171 980
R201	Resistor	Fixed, composition, 220K, 1/2w, 10%	32-202 622

ELECTRICAL PARTS LIST (cont)

Schematic Reference	Part	Description	Varian Part No.
R202	Resistor	Fixed, composition, 470K, 1/2w, 10%	32-202 647
R203	Resistor	Fixed, composition, 47K, 1/2w, 10%	32-202 547
R204, R205	Resistor	Fixed, composition, 330K, 1/2w, 10%	32-202 633
R206	Resistor	Fixed, composition, 22K, 1/2w, 10%	32-202 522
R207	Resistor	Fixed, composition, 4.7K, 1/2w, 10%	32-202 447
R208	Resistor	Fixed, composition, 470K, 1/2w, 10%	32-202 647
R209	Resistor	Fixed, composition, 10K, 1/2w, 10%	32-202 510
R210	Resistor	Fixed, composition, 1-meg, 1/2w, 10%	32-202 710
R211	Resistor	Fixed, composition, 4.7K, 1/2w, 10%	32-202 447
R212	Resistor	Fixed, composition, 470K, 1/2w, 10%	32-202 647
R213	Resistor	Fixed, composition, 4.7K, 1/2w, 10%	32-202 447
R214	Resistor	Fixed, composition, 470K, 1/2w, 10%	32-202 647
R215	Resistor	Fixed, wire-wound, 500-ohm, 5w	35-289 350
R216		See Servo Chassis	
R217	Resistor	Fixed, composition, 470K, 1/2w, 10%	32-202 647
R218	Resistor	Variable, composition, 1-meg	36-893 710
T201	Transfmr	Output	900766
T202	Transfmr	Power	900767
V201	Tube	Electron, Type 12AX7	61-901 678
V202 (9-20mv)	Tube	Electron, Type 12AX7	61-900 810
V202 (21-50mv)	Tube	Electron, Type 12AT7	61-900 799
V202 (51-100mv)	Tube	Electron, Type 12AU7	61-900 801
V203	Tube	Electron, Type 6AQ5	61-900 375
V204	Tube	Electron, Type 6X4	61-900 715
	Cable	2-conductor, shielded (22-inch length)	81-622 298
Servo Chassis:			
B201 (G-11A)	Motor	Balancing, high-impedance (distinguished by #20 AWG cloth-covered leads; also C212 is 1-μf, 200v and is connected to plate side of T201)	940389-02

ELECTRICAL PARTS LIST (cont)

Schematic Reference	Part	Description	Varian Part No.
B201 (G-11)	Motor	Balancing, low-impedance (distinguished by #22 AWG plastic-covered leads; also C212 is 8-μf,450v and is connected to center tap of T201)	940389-01
C210A, C210B (G-11)	Capacitor	Fixed, electrolytic, 8-8-μf,450v (for low-impedance balancing motors)	41-547 172
C210 (G-11A)	Capacitor	Fixed, electrolytic, 8-μf,450v (for high-impedance balancing motors)	41-547 882
C212 (G-11A)	Capacitor	Fixed, paper, 1-μf,200v (for high-impedance balancing motors)	41-547 172
P205	Connector	Plug	51-183 980
R216	Resistor	Variable, wire-wound, 5K, 5%, 0.5% linearity (slidewire)	901501
Power Chassis:			
C211 (G-11)	Capacitor	Fixed, paper, 0.05-μf,400v	41-348 787
F201	Fuse	Type 8 AG, 1-amp	67-121 410
F202 (G-11)	Fuse	Type 8 AG, 1-amp	67-121 410
L201 (G-11A)	Filter	Interference	902304
L201 (G-11)	Inductor	Filter	940647
L202	Inductor	Filter	940648
L202 (G-11)	Inductor	Filter	940648
P206	Cable	Power (including plug), 3-wire	901187
S201	Switch	Toggle, SPST	71-199 980
S202	Switch	Toggle, DPDT	71-149 960
TB201	Board	Terminal	901800
G-11	Block	Fuse	55-199 992
G-11A	Holder	Fuse	55-199 998

ELECTRICAL PARTS LIST (cont)

Schematic Reference	Part	Description	Varian Part No.
Chart-Drive Assembly:			
		NOTE: Part numbers shown below are for replacement chart-drive motors ONLY and do not include spur gear and friction clutch shown in Figure 17. If entire motor assembly, including gear and clutch, is desired, specify Chart-Drive Motor Assembly AND basic chart speed (see Data Sheet for list of chart speeds available)	
B202, B203 (if used)	Motor	Chart-drive, chart speed = 1/2-inch per hour	940657-01
	Motor	Chart-drive, chart speed = 1 inch per hour	940657-03
	Motor	Chart-drive, chart speed = 2 inches per hour	940657-04
	Motor	Chart-drive, chart speed = 3 inches per hour	940657-07
	Motor	Chart-drive, chart speed = 8 inches per hour	940657-05
	Motor	Chart-drive, chart speed = 12 inches per hour	940657-08
	Motor	Chart-drive, chart speed = 15 inches per hour	902365-05
	Motor	Chart-drive, chart speed = 20 inches per hour	940657-09
	Motor	Chart-drive, chart speed = 24 inches per hour	940657-16
	Motor	Chart-drive, chart speed = 30 inches per hour	940657-10
	Motor	Chart-drive, chart speed = 1 inch per minute	940657-11
	Motor	Chart-drive, chart speed = 2 inches per minute	940657-12
B202, B203 (G-11)	Motor	Chart-drive, chart speed = 4 inches per minute	901899-01
	Motor	Chart-drive, chart speed = 6 inches per minute	901899-02
	Motor	Chart-drive, chart speed = 8 inches per minute	901899-03

ELECTRICAL PARTS LIST (cont)

Schematic Reference	Part	Description	Varian Part No.
B202, B203 (G-11A)	Assembly	Chart-drive motor, high-speed, chart speed = 4 inches per minute	940503-15
	Assembly	Chart-drive motor, high-speed, chart speed = 6 inches per minute	940503-16
	Assembly	Chart-drive motor, high-speed, chart speed = 8 inches per minute	940503-17
	Capacitor	Fixed, paper, 1-μf, 400v (for high-speed G-11A motors)	41-348 799
	Resistor	Fixed, wire-wound, 750-ohm, 10w (for high-speed G-11A motors)	35-388 375

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